MACHINERY
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DIE-CASTING—1

THE PROCESS, MACHINERY AND DIES USED IN AN INTERESTING MANUFACTURING OPERATION

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DIE-CASTING, a comparatively recent method for producing finished castings, is rapidly proving itself an important factor in the economical manufacture of interchangeable parts for adding machines, typewriters, telephones, automobiles and numerous other products where it is essential that the parts be nicely finished and accurate in dimensions. The term "die-casting" is self-explanatory, meaning "to cast by means of dies"; described briefly, the process consists of forcing molten metal into steel dies, allowing it to cool in them, and then opening the dies and removing the finished casting. It is the purpose of these articles to give a general outline of the die-casting process, showing its possibilities and limitations, and also to give a description of the die-casting machinery and its operation, of the fundamental principles involved, and of the methods used in the die-making. Illustrative examples of the best types of dies, based on results obtained from actual experience, will also be given.

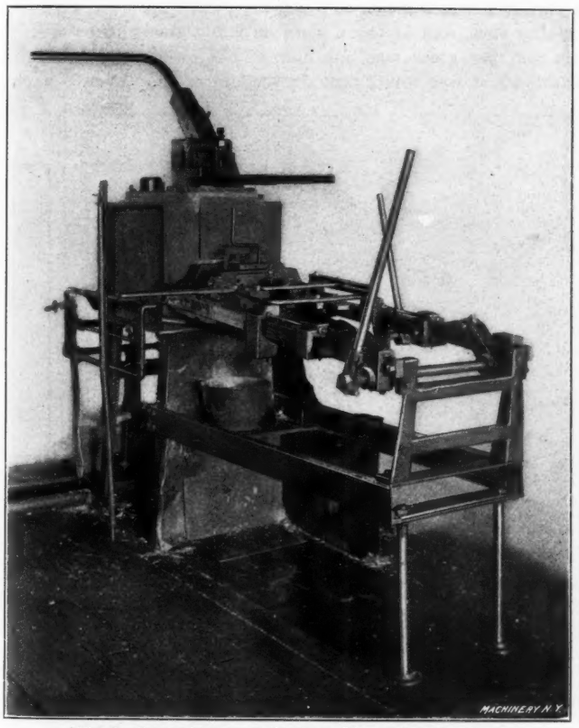

Fig. 1. General View of the Soss Die-casting Machine

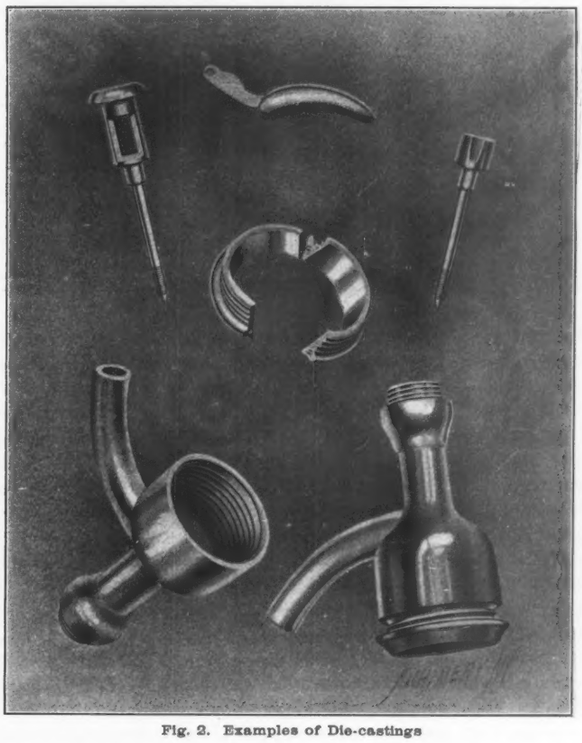

Fig. 2. Examples of Die-castings

Origin of Die-casting

The origin of the die-casting process is somewhat difficult to ascertain. We may look into the history of type founding and find that away back in 1838, the first casting machine for type, invented by Bruce, was a machine that involved the principles of die-casting as it is practiced today. More recently, in 1885, Otto Mergenthaler brought out the linotype machine, that wonderful product of the human mind that has revolutionized the printing industry. The linotype machine is a good example of a die-casting machine. However, as we interpret the word today, die-casting is a broader term than type-casting or linotyping, although its development without doubt is due to the success of the linotype machine. It is doubtful if die-casting, properly speaking, was originated until about fifteen years ago, and it is certain that it is only during the past few years that the activities in this line have been very noticeable.

Necessity is the mother of invention! One of the first experiments in the direction of die-casting was undertaken to get out some mold parts cheaply enough to leave a profit on a job that was commencing to look dubious—from the financial side. The molds were for making rubber plates about three inches square and one-eighth inch thick, the top side of which was decorated with fine raised scroll work; it was this latter feature that gave the trouble. After wasting much time and money trying to stamp the mold parts, a metal-tight box was made as shown in Figs. 4 and 5 with a block screwed in it, the purpose of which was to shape the mold impression and impart to it the scroll design. As shown, the ends of the box were removable, being screwed on. This box was placed under a screw press and a straight plunger that just filled the top of the box was fitted to the head of the press. After the two were lined up, molten type metal was poured into the box, and as soon as the metal had cooled to the "mushy" state, the ram of the press was forced down as shown in Fig. 5. Next, the ends of the box were removed, the screw holding the block taken out, and the die-casting pushed from the box. The object in having the inclined side to the box was to produce a piece shaped with the proper inclination for its position in the final mold used for casting the rubber plates. The illustrations give an idea of the compression that took place. The die-casting was found to be sharp at the corners and free from flaws, and the scroll work came up in fine shape. Naturally the rest of the mold parts were made in the same way and the job turned from failure into success.

From such simple experiments as these, the die-casting in-

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dustry has developed to its present stage. In view of the advances that have been made in die-casting, it is singular that there are today only about a dozen concerns in the business in this country, but as the subject becomes better understood, and the possibilities of the process are realized, the demand for this class of castings will result in many other firms going into the work, and it is not improbable that a large number of factories will install die-casting plants of their own to aid them in producing better work in a more economical way.

Advantages, Possibilities and Limitations of Die-casting

The greatest advantage of die-casting is the fact that the castings produced are completely and accurately finished when

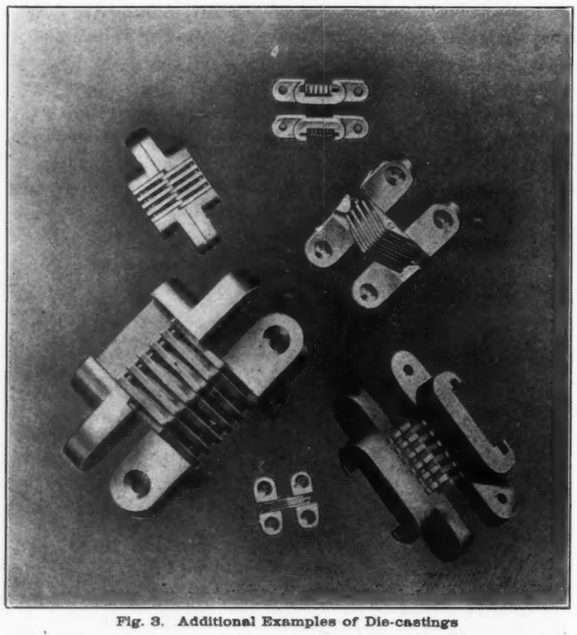

Fig. 3. Additional Examples of Die-castings

taken from the dies. When we say completely, we mean that absolutely no machining is required after the piece has been cast, it being ready to slip into its place in the machine or device of which it is to be a part. When we say accurately, we mean that each piece will come from the die an exact counterpart of the last one; and if the dies are carefully made, the castings will be accurate within 0.001 inch on all dimensions, whether they are outside measurements, diameters of holes or radii. All holes are cast and come out smoother than they could be reamed; lugs and gear teeth are cast in place; threads, external and internal, and of any desired pitch can be cast. Oil grooves can be cast in bearings, and, in a word, any piece that can be machined may be die-cast.

The saving in machining works both ways; not only is all machine work eliminated by the one operation of casting, but the machine tools and the workmen necessary for their operation and up-keep are dispensed with, the expense of building jigs and fixtures is stopped; and no cutters, reamers, taps or drills are required for this branch of the production. In addition, the labor required for operating the casting machines may be classed as unskilled. No matter how intricate and exacting the machine work on a piece has been, and how skillful a workman was required to produce the work when machine-made, the same result may be brought about by die-casting, and usually the work is excelled, and, excluding the die-maker, unskilled men can make the parts.

From a metallurgical standpoint a die-casting is superior to a sand-casting on account of its density, strength and freedom from blow-holes. Also, when the hot metal comes in contact with the cool dies, it forms a "skin" similar to the scale on an iron sand-casting. As the die-casting requires no machining after leaving the dies, this skin increases the wearing qualities of the casting.

The possibilities of die-casting are numerous. By this method of manufacturing it is possible and practical to cast pieces that could not possibly be machined. It is an every-day occurrence to make castings with inserted parts of another metal, as, for instance, a zinc wheel with a steel hub. It is also possible to make babbitt bearings that are harder and better than can be made in any other way. Often there are two or more parts of a device that have formerly been made separately, machined and assembled, that can be die-cast as one piece. In such cases the saving in production is very great. Figures and letters may be cast sunken or in relief on wheels for counting or printing, and of course ornamentation may be cast on pieces that require exterior finish. As to size, there is no reasonable limit to the work that can be cast. One job that is being done at the present time is a disk, 16 inches diameter with a round flange, 1 inch in diameter, around the rim.

"There is no great gain without some small loss," is just as true of a process like die-casting as it is of anything else. The limitations of this work are few, however, and they are here given so as to state the situation fairly. Generally speaking, a part should not be considered for die-casting if there are but few pieces required, because the cost of the dies would usually be prohibitive. Often, however, it happens that because of the large amount of accurate machine work being done on a machine part, it is economical to make a die for the comparatively small number of parts required and die-cast them. A case illustrating this phase of the matter recently occured in actual practice. In getting out an order of two hundred vending machines, it was decided to try die-casting on a part that was difficult to machine. The dies were expensive, costing $200, and as there were only 200 pieces to be cast, the die cost per piece was one dollar; but even with that initial handicap, it was found that on account of the difficult machin-

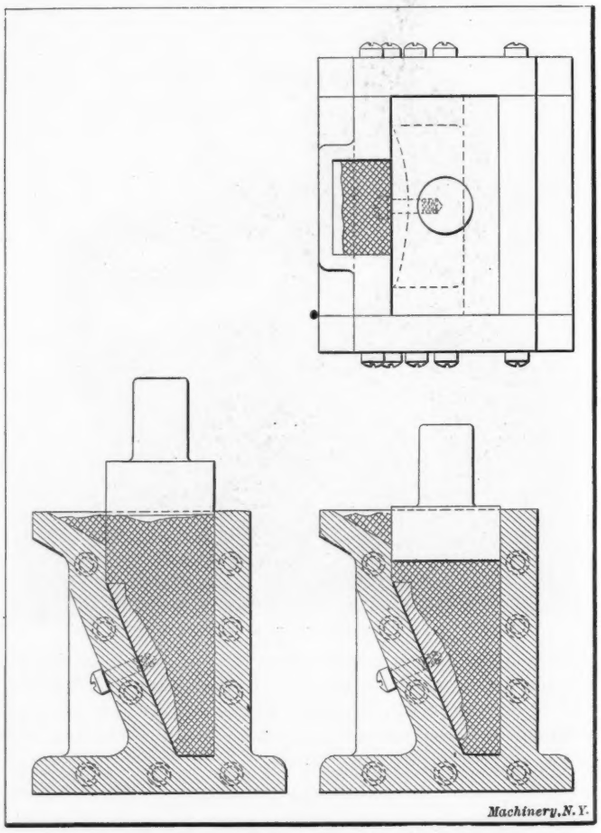

Fig. 4. An Early Experiment in Die-casting — Before Applying Pressure

Fig. 5. An Early Experiment in Die-casting — After Applying Pressure

ing that had formerly been required, the die-cast parts effected a large saving, and of course the results were superior.

A rough part that would require little or no machining should not be die-cast, because pound for pound, the die-casting metals cost more than cast iron or steel. The casting machine cannot make parts as rapidly or of as hard metals as the punch press or the automatic screw machine. For this latter reason a part that necessarily must be made of brass, iron or steel, cannot be die-cast, although mixtures approximately equal in strength to iron and brass are readily die-cast. To

give added strength to a die-cast part it is often advisable to add webs and ribs or to insert brass or iron pins at points that are weak or subject to hard wear. Roughly speaking, it is the part that has required a good deal of accurate machine operations that shows the greatest difference in cost when die-cast, and sometimes the saving is as great as 80 per cent.

The Metals Used in Die-casting

The metals that produce the best die-castings are alloys of lead, tin, zinc, antimony, aluminum and copper, and the bulk of the die-castings made at the present time are mixtures of the first four of these metals. From them, compositions may be made that will meet the requirements of nearly any part.

For parts that perform little or no actual work, save to "lend their weight", such as balance weights, novelties and ornaments for show windows, etc., a mixture consisting principally of lead, often stiffened with a little antimony, is used. There is but little strength to this metal, but it is used because of its weight and low cost. For parts that are subject to wear, such as phonograph, telephone, gas-meter and adding machine parts, an alloy composed of zinc, tin and a small amount of copper is used. This alloy may be plated or japanned, and is a good metal to use on general work.

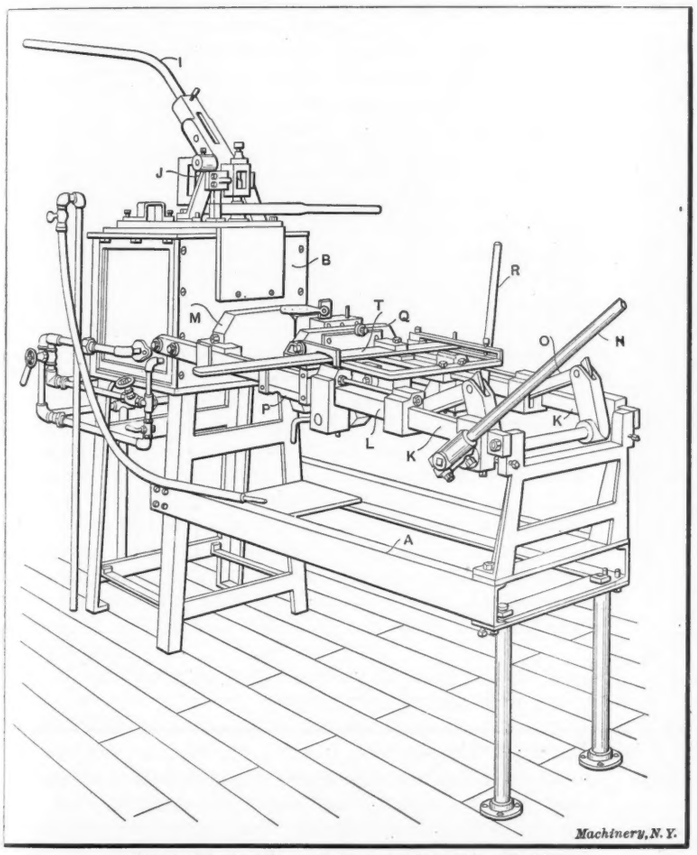

Fig. 6. Working Parts of the Soss Die-casting Machine

Another metal, used chiefly for casting pieces that have delicate points in their design but are not subjected to hard wear, consists principally of tin alloyed with lead and zinc to suit the requirements of the work. This mixture casts freely, and the finished castings come out exceptionally clean. Still another metal, used chiefly for casting pieces that have letters and figures for printing, is similar to the standard type metal: 5 parts lead and 1 part antimony; but if there are teeth cast on the sides of the printing wheel a harder mixture will be required to give longer life to the gears.

The following mixtures are typical of die-casting or "white brass" alloys: copper, 10 parts; zinc, 83 parts; aluminum, 2 parts; tin, 5 parts. Another is copper, 6 parts; zinc, 90 parts; aluminum, 3 parts; tin, 1 part. Another containing antimony is copper, 5 parts; zinc, 85 parts; tin, 5 parts; antimony, 5 parts. Shonberg's patented alloy is copper, 3 parts; zinc, 87 parts; tin, 10 parts. Alloys containing 15 to 40 per cent copper and 60 to 85 per cent zinc are brittle, having low strength and low ductility. An alloy of 8 per cent copper, 92 per cent zinc has greater resilience and strength but not the ductility of cast zinc.

Aluminum may be cast, but it is a difficult metal to run into thin walls and fine details; it plays, however, an important part in some good mixtures used for die-casting. Experiments are now being conducted for die-casting manganese bronze, and it is said that some very good castings have already been made. Its wearing qualities are so valuable that it is particularly desirable for making die-castings.

The Die-casting Machine

The three important requisites for good die-casting are the machine, the dies and the metal. The casting machine is fully as essential as either of the other requisites, and although there are a number of different styles of casting machines in use, each of which has its advantages over the others, especially in the eyes of their respective designers, the fundamental principles upon which they all operate are the same. In each there is the melting pot and the burner, the cylinder and the piston for forcing the metal into the dies, and the dies with the opening and closing device. In some machines pressure is applied to the metal by hand, in others power is used, and in still another class the metal is forced into the dies with compressed air. The provisions for opening and closing the dies vary in the different machines; there are various means employed for cutting the sprue, and the styles of heaters are numerous.

One or two of the largest firms in the die-casting industry have automatic casting machines for turning out duplicate work in large quantities very rapidly. These machines are complicated and are only profitable on large quantities of work, and for that reason their use is not extensive. In general, their operating principles are the same as in the case of the hand machines, but provision is made for automatically opening and closing the dies, compressing the metal, and ejecting the castings.

The Soss Die-casting Machine

The Soss die-casting machine, manufactured and sold by the Soss Manufacturing Co., Brooklyn, N. Y., is one of the latest of the die-casting machines, and is the first die-casting machine to be placed on the open market. This machine is shown in Figs. 1 and 6, and in section in Fig. 7. The Soss Manufacturing Co. originally manufactured invisible hinges exclusively. At the advent of the die-casting era, they commenced to make these hinges from die-castings, and placed orders with a leading die-casting concern amounting to thousands of dollars each year. After the die cast hinges had been on the market for a short time, complaints commenced to come in, some to the effect that the hinges were breaking and others that the hinges were corroding. Either of these faults was serious enough to blast the reputation of the hinge, but the first trouble, breakage, was the more important. Examination of the broken hinges showed that the castings were porous and full of flaws, and as the makers of the castings could not produce castings sufficiently strong for the hinges, Mr. Soss started to experiment for himself. This experimenting led to the production of the Soss die-casting machine.

Referring to the illustrations Figs. 6 and 7, *A* is the base and frame of the machine, *B* is the heating chamber located at one end of the machine, and within this heating chamber is the tank *C*, shown in Fig. 7. This tank contains the metal from which the die-castings are made, and the metal is heated by the burners *D*. These burners are fed by air and gas through piping on the side of and beneath the furnace. To facilitate lighting the burners and inspecting their condition at any time, there is an opening (not shown) through the firebrick lining of the furnace and the outer iron wall, on a level with

the top of the burners. There is also another opening through the furnace wall to allow the gases due to the combustion to escape. Through the bottom of the tank, well to the inner side of the furnace, runs the cylinder *E*. Below the bottom of the tank, the cylinder makes a right-angle turn, extending through the furnace wall and terminating just outside of the wall. The orifice of this cylinder is controlled by gate *F*. In that part of the cylinder that extends upward into the tank, there is an opening *G* that allows the molten metal to run into the cylinder from the tank. Working in this cylinder, is the piston *H*, that is used in forcing the metal into the dies. The compression lever *I*, hinged over the inner furnace wall, is kept normally raised by spring pressure, and is connected to the piston by means of the link *J*.

At the opposite end of the machine from the furnace, is the mechanism for operating the dies. This mechanism consists of a pair of square rods *K*, upon which are mounted the sleeves *L*. These sleeves have a long bearing surface and are attached to the die-plate *M*. Lever *N* at the end of the operating mechanism controls the movement of these sleeves by means of rubber hose connected to the air piping. This hose is used for cleaning out the dies after each casting operation.

Operation of the Die-casting Machine

The metal for the die-casting machine is mixed in the proper proportions for the work in hand by means of a separate furnace, before being poured into the tank of the machine itself. The burners are lighted and the dies are set up on the two die-plates. As soon as the machine has "warmed up", so that the metal is in a thoroughly melted condition, the sprue-cutting lever *T* is thrown back, leaving a clear passageway to the die cavities. Lever *R* is pulled backward, thus bringing die-plate *Q* up to die-plate *M*, which operation closes the two halves of the die. Then lever *N* is thrown forward, thereby bringing the closed die up to the body of the machine, with the nozzle in close contact with the outlet of the cylinder. Next, the gate *F* is opened, and the man at the compression lever *I* gives the lever a quick, hard pull, forcing the metal in the cylinder downward and into the dies. The molten metal literally "squirts" into the dies. Gate *F* is now closed;

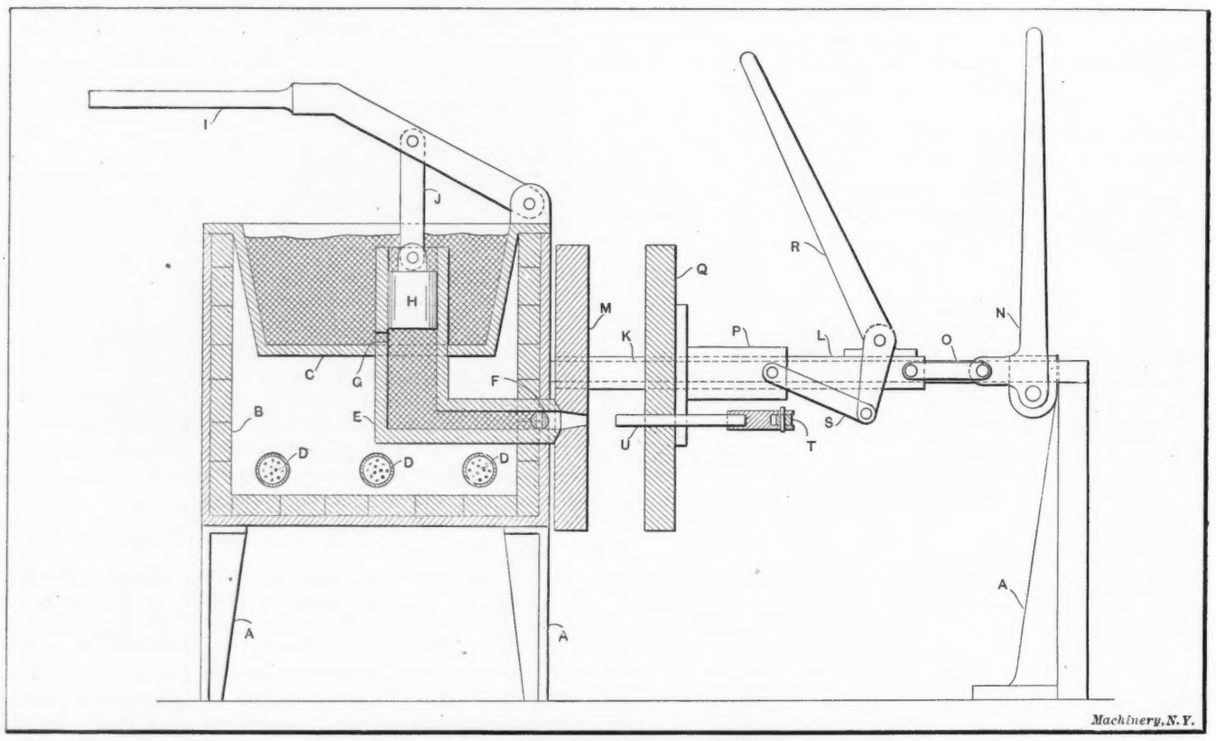

Fig. 7. Section of Soss Die-casting Machine

links *O*. Upon these sleeves is mounted a secondary set of sleeves *P*, attached to the other die-plate *Q*, and whose movement is controlled by lever *R*, through links *S*. This second set of sleeves is free to travel with the first set, and in addition has an independent movement of its own on the primary sleeves. It is the function of lever *R* to bring die-plate *Q* up to die-plate *M* by means of links *S* and sleeves *P*; and it is the function of lever *N* to bring both of the die-plates up to the outlet of the cylinder by means of links *O* and sleeves *L*. This system of sleeve-mounting is one of the distinctive patented features of the Soss machine. The orifice of the cylinder *E* is conical in shape and exactly fits the cup-shaped opening in die-plate *M*, so that when the two are brought together, the joint is metal tight. At the center of this opening, and extending through the die-plate *M*, is an opening that leads to the dies mounted on the inner faces of the two die-plates, and a continuation of this opening extends through die-plate *Q* in which the sprue-cutter *U* works. Attached to the outer side of this die-plate are two slotted brackets. In the slot of one of these is pivoted the lever *T*, and in the slot in the opposite bracket are bolted two stops that limit the motion of the lever. This lever operates the sprue cutter *U*, that works through the opening in die-plate *Q*. The sprue-cutting mechanism is best shown in Figs. 6 and 7. At the left of Fig. 6 may be seen a lever *N* is pulled back to remove the dies from the cylinder outlet; and the sprue-cutting lever *T* is pushed forward, cutting off the sprue and pushing it out of the nozzle into the kettle placed beneath it. The lever *R* is pushed forward, and a finished casting is ejected from the dies.

An important advantage that this machine has over other die-casting machines is the fact that the metal for the castings is taken from the *bottom* of the melting pot, whereas most other machines use metal from the top of the tank. At the bottom of the tank the metal is always the best, as it is free from impurities and dross; hence, there is little chance for the formation of blow-holes. A handful of rosin thrown into the melting tank occasionally helps to keep the metal clean, but the metal nearest the surface always contains more or less foreign matter.

While this description of the operation of the die-casting machine may convey the idea that the process is a slow one, as a matter of fact, the time required is, on the average, not over a minute and a half for turning out a finished casting. With the ejection of the casting from the dies, the product is completed, in theory; but in practice there are always a few small thin fins, caused by the air vents or by improperly fitted portions of the dies. It is, however, but the work of a few seconds to break off these fins, and unless there are many of them, or

they are excessively thick, they are detrimental neither to the quality nor the quantity of finished castings.

Points on the Operation of the Die-casting Machine

We have now taken up the description and general operation of the die-casting machine, but like every other machine, there are numerous little kinks and practices in its working the application of which makes the difference between good and poor die-casting. Some of these points are here given:

The casting machine is best operated by three men, one of whom attends to the compression lever and the metal supply in the tank. The other two men stand on each side of the die-end of the machine, and it is their duty to operate the sprue-cutter, open the dies and remove the finished casting, clean the dies with air and close them, throw back the die-plates to their casting position over the cylinder outlet, and do any other work incident to the operation of the machine. While it requires three men to operate a die-casting machine in the best manner, the man who attends to the compression lever has a good deal of spare time between strokes and if two or even three of the machines are conveniently placed, one man can easily pull levers for all three.

The metal should be kept just above the melting point and at a uniform temperature. If the metal is worked too cold, the result will manifest itself in castings that are full of seams and creases, and it will be difficult to "fill" the thin places in the dies. If, on the other hand the metal is allowed to get too hot, the die will throw excessively long fins, the castings will not cool as quickly in the die, and consequently they cannot be made as rapidly. On account of the importance of keeping the metal at a uniform heat, the fresh metal that is added to that in the tank from time to time, is kept heated in a separate furnace. Therefore, when the metal in the tank gets low, the new supply does not reduce the temperature of the metal being worked. Some casters use a thermometer to indicate the heat of the metal.

Casting-dies require lubrication frequently. Just how often they should be lubricated depends on the shape of the die, the composition of the casting metal, and the general performance of the dies. Bees-wax is the common lubricant, and the lubrication consists in merely rubbing the cake over the surfaces of the dies that come in contact with the casting metal. In die-casting large parts, the dies must be kept cool by some artificial means, for hot dies are conducive to slow work and poor castings. To reach this end, large dies are sometimes drilled and piped so that water may be circulated through them to keep them cool.

In the Soss machine, the burners are so placed that the metal in the cylinder is kept at a slightly higher heat than that in the tank proper. This condition is brought about by having the cylinder directly over the burners. The value of this feature lies in the fact that gas is not wasted in heating the entire tank full of metal to this higher heat, but still the metal under compression is at the required temperature. The gas consumption of the average die-casting machine is about 100 cubic feet per hour.

The speed at which die-castings may be produced varies with the size of the castings being made, the composition of the metal being cast, and the style of dies that must be employed. This latter restriction may involve separate brass or steel pieces that must be placed in the dies before each operation so that they will be inserted in and become a part of the finished casting. The dies may be difficult of operation on account of draft problems or pins and screws that must be inserted in the dies and removed from each casting before another can be made. These different types of dies will be more fully described in the next installment. Taken as a whole, from ten to sixty pieces per hour are the maximum limits for speed in die-casting, and with a well-working die, of simple construction, a speed of forty pieces per hour is considered good production. It is possible, however, when the castings to be produced are small in size and simple in shape, to gate a number of them together, or rather to construct the dies so that six or more castings may be made at once. By this means it is often possible to cast five or six thousand pieces per day of ten hours, on a hand die-casting machine.

SOME SUGGESTIONS FOR INDEXING BOOKS

By JOHN S. MYERS*

As an experiment, the writer once asked several engineers for information which necessitated the consultation of a book and observed their methods of locating it. Almost invariably they leafed through the book entirely neglecting the index. Why? They *knew* of the information, had some recollection of how it was treated, of its location in the book or of the illustrations accompanying it, and hoped to catch a glimpse of one of these illustrations, thus locating the subject sought. The index provided was treated as a last resort. This suggested the idea that there was something fundamentally wrong with the index, the first point which suggested itself being that it was wrongly placed, at the back of the book, inside the covers, whereas it should have been on the exterior where it would have stared them in the face.

Fig. 1 represents an index applied to the exterior of a small dictionary. Note that the letters, instead of being inside the

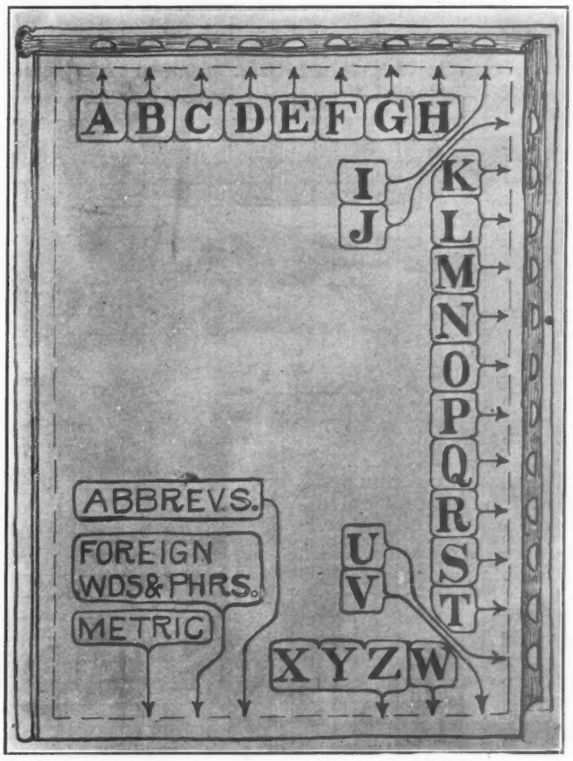

Fig. 1. Suggested Method of Indexing a Small Dictionary

thumb-holes, are on the cover where they are more readily seen. The distinctive feature, however, is the employment of lines and arrows directing the attention from a word or character to the thumb-notch it refers to. This makes it possible to utilize the entire face of the cover for the index. There are, however, points besides the location of an index which are at fault. Antiquarians tell us that away back in the ages hieroglyphic writing came into existence. Now why was this the first form of written language? The answer probably lies in the answer to the question, "Why are ideas most readily suggested to the mind by the medium of sight?" Suppose we moderns go back to first principles, back to the origin of written language. The lesson we learn is that a *picture* of an article is *more readily recognized* than the printed word. This principle is recognized in advertising and much ingenuity, not to mention money, is expended upon illustrating, but in the field of indexing we find it entirely ignored.

Some of the arguments in favor of the employment of pictures or symbolical designation in connection with an index are as follows: A picture more readily conveys an idea to the mind than the printed word, insomuch as it is perceived by a

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simpler mental process. There is more distinction between the appearance of two different pictures than two different words; thus, the location of the desired picture is seen at a glance, whereas the desired word can only be located by a search among all the words. In the case of a word index, the last word you find is the one you were looking for, whereas in the case of pictures, the first picture you see is the one you have your mind's eye open to perceive, *i. e.* the picture you are looking for.

The mind is enabled to perceive more readily by the aid of such pictures because it is aided by the very important faculty, *memory*. One cannot remember the precise word under which a subject is indexed, hence the necessity for cross-indexing with its attendant lengthiness, but with a picture index one would naturally, because of its novelty and prominent location upon the book, give the index itself some little thought; and, since each picture leaves a mental picture, memory directs the eye. This is in fact the mental process which causes one to ignore the present forms of index and thumb over the leaves in an attempt to locate a subject one has some recollection of.

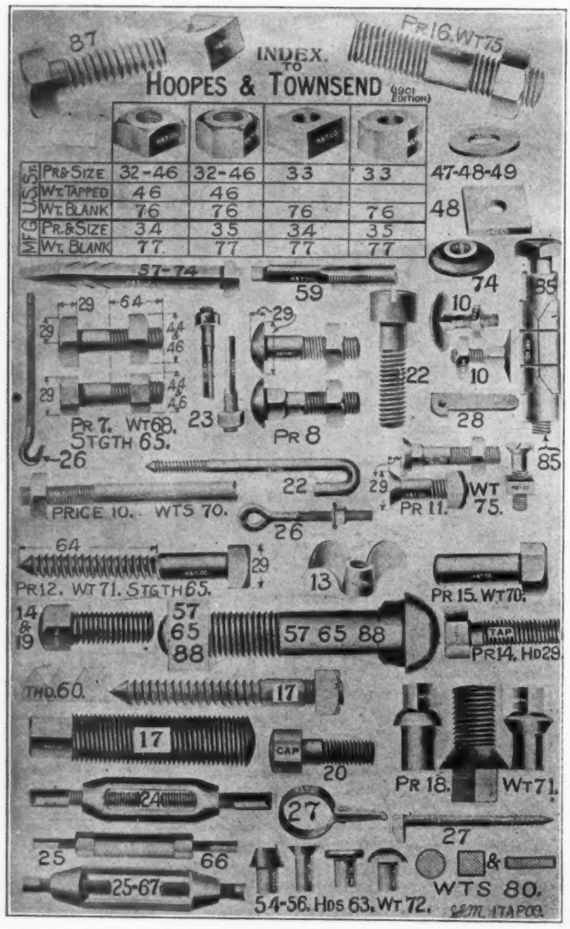

INDEX TO HOOPES & TOWNSEND
PR 16. WT 75
PR 7. WT 69. STGTH 65.
PR 8
PRICE 10. WTS 70.
PR 11. WT 75.
PR 12. WT 71. STGTH 65.
PR 15. WT 70.
PR 14. HD 29
PR 18. WT 71.
54-56. HDS 63. WT 72.
WTS 80.

Fig. 2. Method Applied to a Catalogue of Screws, Bolts and Nuts, etc.

Granting the foregoing, it would seem easier and more natural to adapt the index to these mental tendencies than to attempt changing the make-up of the individual to suit the index. In other words, the present style of indexing is not natural—it has no psychological foundation. Again, one is frequently unfamiliar with the trade name or other proper designation of an object, but may easily be able to recognize its picture. This is especially true of small details listed in catalogues, for sometimes a part is known by several names.

The employment of pictures permits a logical arrangement of correlated subjects; for instance, in a trade catalogue, turnbuckles and sleeve-nuts, taps and dies, cap-screws and tap bolts, track bolts and fish-plates, constitute related details, and may be grouped by the proximity of their pictures. In an alphabetically arranged index their names are widely separated. The use of a picture index upon the exterior of a catalogue shows at a glance the subject matter within. It aids the customer to locate information, and consequently aids the advertiser. Fig. 2 is a rough attempt at preparing such an index for a catalogue. The method of preparing this illustration was to clip the pictures from the contents of the catalogue, arrange them upon a large sheet reduced by the camera to the size of the cover; consequently, the relative size of the various pictures is precisely as they were in the catalogue, which gives undue prominence to certain subjects while others are rather small.

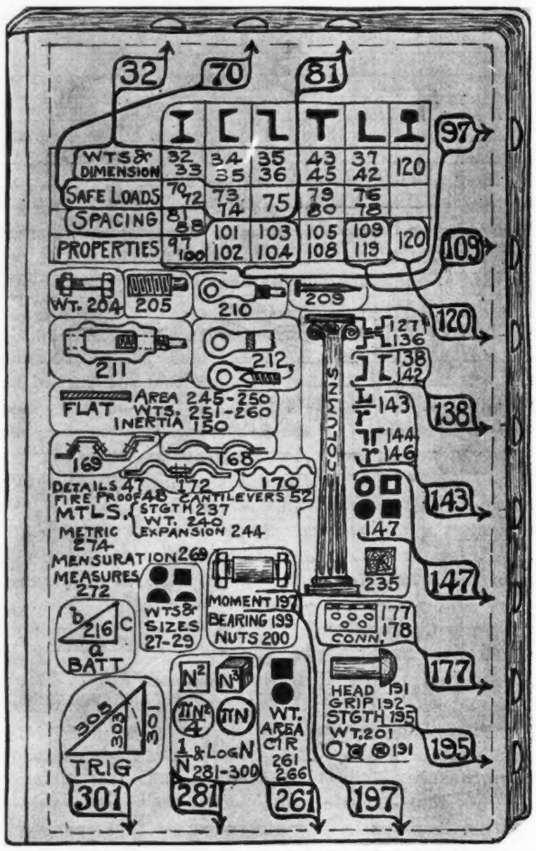


Fig. 3. Method Applied to Carnegie Steel Co.'s Hand-book

The precise manner in which such an index should be compiled would, of course, depend upon the nature of the book; for instance, a work on the anatomy of the eye might have one or more large sectional views of an eye on the exterior with page numbers and lines connecting the page numbers with the various parts, while if the subject was the general anatomy of the human body the pictures would be of the entire body, the numbers referring to the chapters relative to the various organs only. A hand-book on steam boiler construction might

Fig. 4. Catalogue Cover which would lend itself to the Method of Indexing Proposed

have a picture of each general type of boiler with large page numbers for the beginning of each subject and smaller numbers for the details. Each book would have to be made the subject of special study—mere routine clerical compilation would not suffice. In some cases the index would be compiled with special regard to who constituted the largest users of the book.

In Fig. 3 is shown an index to the "Carnegie Steel Co.'s Hand-Book," especially compiled for structural draftsmen, the one class of men who continually use such a book. Note that the matter referred to in such a book is all indexed on the small cover; the matter most frequently used is provided with thumb notches. Fig. 4 is a reproduction (reduced) of an attractive cover, but it is ornamental only, not useful. By the addition of page numbers and the proper grouping of the contents it could be made an index.

Of course there are abstruse subjects such, for instance, as "The Psychic Life of Micro-organisms," to which this method of indexing would not be applicable. The scheme, however, could be applied to almost any subject in the line of mechanics, and suggests some ideas applicable to other than technical literature. The writer believes that one of the most salutary effects resulting from the use of such an index would be a more logical grouping of the contents of the book so indexed which is a much-needed reform in the case of the majority of hand-books and catalogues.

* * *

LEAVING TOOLS AROUND

A naval engineer has been reduced several numbers because he left a monkey wrench in one of the cylinders of the ship where he was employed. It was not because the wrench was of much value, and because his Uncle Samuel had to go out and purchase another, but because the wrench was in the way. It wasn't needed in the cylinder. It was foreign matter, not necessary to the running of the engine or to the speed of the boat. It added nothing to the fighting qualities of the craft, and that is what the Government is after principally. In fact, the wrench in the cylinder was a detriment and a hindrance to the smooth working qualities of the boat's machinery. There was no room for it in the cylinder, and when the great engine was started up something, of course, had to go. The monkey wrench being a hard nut to crack, it naturally followed that the cylinder did all the cracking. The cylinder came to grief, and in the common run of things naval the engineer followed the same course.

We are sorry for the engineer, but glad the naval board has meted out this just punishment. It makes us feel more at ease over the safety of our country not to have monkey wrenches in our cylinders and, to bring the lesson ashore, it will help some when we are undergoing repairs at the hands of the dentist or the surgeon who is using wrenches and scissors and chisels, etc., in the region of our own cylinders. It is a matter of common knowledge that all sorts of trinkets, such as lances, needles and shears, have been sewed up in the human system following a successful operation. Teeth have been found in the stomach long after a siege of extraction and distraction at the dentist's.

A pair of scissors left in a man's interior is of no more use to him than a monkey wrench left in a cylinder. The surgeon may not miss the scissors, but the patient misses the room he had before the scissors usurped it. Space in a cylinder or in a man's anatomy is valuable, and the engineer or surgeon who uses such space for cold storage for tools ought to be reduced, not only in numbers, but to a pulp.—*Boston Herald.*

* * *

The British Consul-General at Kobe, Japan, reports that the proportion of the imports of British electrical machinery has greatly increased over that of German and American goods, and states that British electrical machinery is highly appreciated by the Japanese, even though the British prices are sometimes higher. The cheap classes of machine tools are being produced in ever-increasing quantities by the Japanese themselves. The designs apparently are taken from foreign models.

EXTERNAL CUTTING TOOLS*—1

PRACTICE FOR THE BROWN & SHARPE AUTOMATIC SCREW MACHINE

By DOUGLAS T. HAMILTON†

The subject of external cutting tools is of wide scope, embracing all the tools which are used in removing material from the external diameters of the work. The most common tools used for external work are circular forming tools, box-tools, hollow-mills, swing tools, taper-turning tools, angular cutting-off tools, shaving tools and other tools of special designs. All the tools mentioned, with the exception of circular form and cut-off tools, which were described in the March and April, 1910, issues of MACHINERY, will be described in this and subsequent articles. External cutting tools are made of different designs to suit the conditions of the work on which they are to be used; therefore a detailed description of the construction and use of each tool will be given.

As box-tools are used extensively on the automatic screw machines, and as they are the most common of all the tools used for external work, a detailed description will be given of their various parts, functions, and applications.

Preparing Work for Turning

Before reducing the diameter of the work by means of a box-tool or other external cutting tool of a similar type, it is necessary to chamfer the front end of the work to permit,

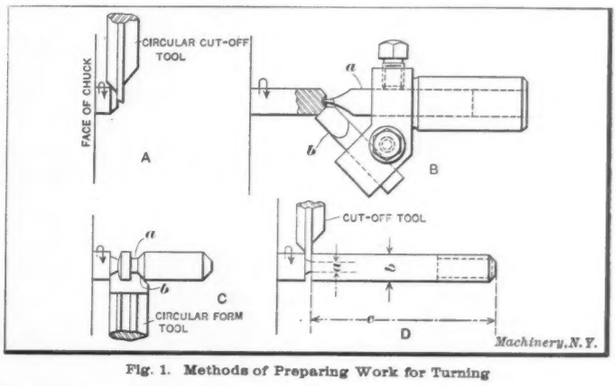


Fig. 1. Methods of Preparing Work for Turning

or rather to facilitate, the starting of the box-tool cutter on a light cut, until the supports are in position to steady the work. Pointing or chamfering the end of the work also facilitates the setting of a hollow-mill concentric with the work.

One method of pointing the end of the work is shown at *A* in Fig. 1. Here the circular cut-off tool has an angular projection on its face next to the chuck, which points the bar before it is fed out for the next piece. This method is generally used when the work is not very long, and runs practically true. When it is necessary to cut a thread on a piece, the beveled end of the bar is made small enough to facilitate the starting of the die.

It is sometimes found impossible to point the bar with the cut-off tool owing to various conditions, and in this case the bar is usually pointed by a combination centering and

* For additional information on this and kindred subjects published in MACHINERY, see: "Cutting Keyways in an Automatic Screw Machine," "Increasing the Product of Automatic Screw Machines," "Setting Screw Machine Stops," "Making a Large Stud on the No. 00 Brown & Sharpe Automatic Screw Machine, December, 1910; "Internal Cutting Tools," September and October, 1910; "Setting-up Tip for Screw Machines," October, 1910; "Measuring Screw Machine Cams," September, 1910; "Designing Screw Machine Tools and Cams," August, 1910; "Threading Operations," June and July, 1910; "A Formed Toolpost and Recessing Tool for Screw Machine Work," May, 1910; "Examples of Box-Tool Design," May, 1910; "Unusual Work Done on the Automatic Screw Machine," April, 1910; "Experiments with Automatic Screw Machine Feed Fingers," March, 1910; "Circular Form and Cut-off Tools," March and April, 1910; "Tool-holder Design," February, 1910; "A Formed Tool Problem," January, 1910; "Don'ts for Screw Machine Operators," November, 1909; "Cutting Helical Gears on the Brown & Sharpe Automatic Screw Machine, April, 1909; "Knurls and Knurling Operations," June and July, 1909, engineering edition; "Attachments for Cutting Squares and Hexagons in Automatic Screw Machine," November, 1908, engineering edition; "Some Interesting Automatic Screw Machine Work," November, 1908; "Making Watch Parts in the Commercial Automatic Screw Machine," June, 1908; "Directions for Camming the Brown & Sharpe Automatic Screw Machine," September, 1903.

† Associate Editor of MACHINERY.

pointing tool as shown at *B*. This tool can be used when the bar does not project more than three and one-half times its diameter from the face of the chuck, and where the bar is unfinished or of irregular shape. The tool *a* is used for centering the work, thus preparing it for drilling a hole; and the tool *b* is used for pointing the end of the bar.

Another condition is that shown at *C*. Here the form tool precedes the box-tool, necking the bar at *a*. Now if the face *b* of the circular tool were left square and not chamfered, as shown, a ring or washer would be formed by the box-tool cutter, as there would be no resistance to the pressure of the cut and hence the thin ring would break off before all the superfluous material had been removed. This condition was clearly illustrated and described in the March, 1910, issue of MACHINERY and it will not be necessary here to go further into detail.

When it is necessary to turn down a portion of a long cylindrical piece of cold-drawn steel or other material which has a finished surface, and have the part turned concentric with the piece which has not been reduced, it is usually good practice to weaken the bar with the circular cut-off tool as shown at *D*. For this class of work the supporting bushing held in the box-tool should precede the turning tool so that the part turned will be concentric with the finished body of the work. Before turning, the bar is pointed with the circular cut-off tool as shown at *A*.

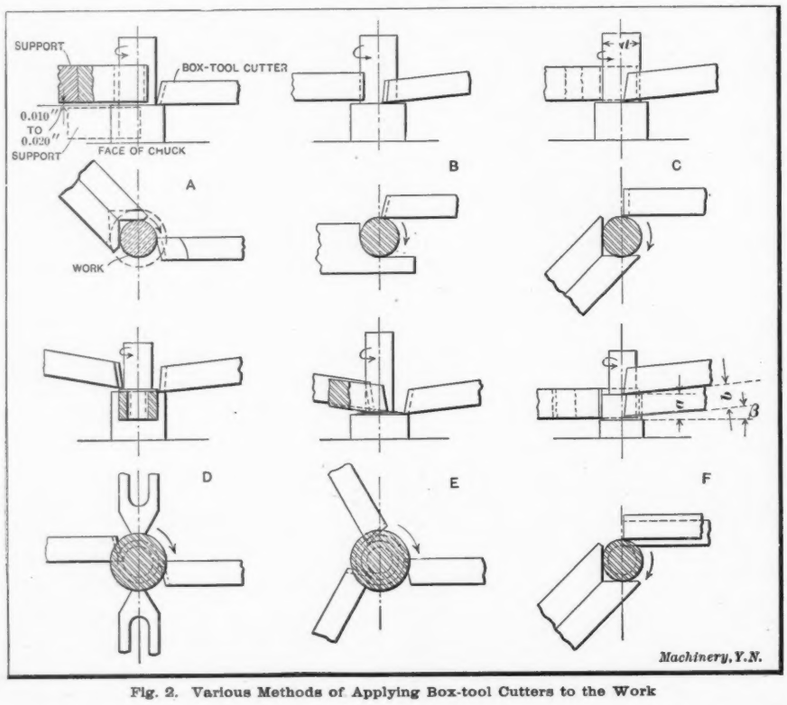


Fig. 2. Various Methods of Applying Box-tool Cutters to the Work

The diameter of the neck *a* should be small enough to allow the bar to be straightened with the box-tool support, so that it will run true. In the majority of cases the neck *a* may be made from 0.3 to 0.5 times *b*, but of course the length of the work *c*, the depth of the chip removed and the feed used will govern largely the diameter of the neck *a*. The material being turned will also affect the diameter of the neck *a* slightly, but in most cases this latter condition can be disregarded. Rods which have short bends in them should not be used, as it will be found impossible to produce a good surface on the part which is turned. The spring collet should also run perfectly true if good results are to be expected.

Application of Box-tool Cutters to the Work

Box-tool cutters are usually applied radially and tangentially to the work. The radial cutter is more commonly used for brass work, while the tangential cutter is used for all classes of steel work, but it is also sometimes used for brass work.

At *A* in Fig. 2 is shown what is termed a "radial cutter," and it can be seen that the cutting edge is set slightly above the horizontal center of the work. The amount that it is set above the center is usually about 0.02 times the smallest diameter of the work being turned. This is the preferable method of applying a turning tool for taking roughing cuts on brass rods. When the stock is rough or of an irregular shape, the cutter should precede the support by an amount equal to from 0.010 to 0.020 inch, but where the bar is cylindrical and has a finished surface, the support for roughing cuts should precede the turning tool, as is shown by the dotted lines.

At *B* is shown what is called a tangential cutter. Here the cutter is set to take a roughing cut from a bar which is not finished, or of irregular shape. Where the bar has a finished surface and is circular in shape, the support is set in advance of the turning tool as was mentioned regarding *A*. The support here shown will be described later.

A tangential cutter set for taking a finishing cut on steel work is shown at *C*. Here the turning tool is set slightly back of the center an amount equal to about 0.10 of the smallest diameter of the work being turned, or *d*. For cutting brass, the tangential cutter is set in line with the center, and, in some cases, a slight amount in advance of the center, especially where less clearance is necessary between the cutter and the periphery of the work.

A method of applying two turning tools for roughing down steel work is shown at *D*, and at *E* is shown a method of applying three turning tools for the same purpose. For taking roughing cuts on brass where an excessive amount of material is to be removed, a hollow-mill is generally used, but the method shown at *D* can sometimes be used to advantage. In the case shown at *E* no supports are used, as the tools support each other. These tools can either be set radially as shown, and a slight amount in advance of each other or can be set tangentially and at varying heights so as to distribute the cuts equally among each of the tools. For taking roughing cuts on steel, it is preferable to set the cutters tangentially to the work.

At *F* is shown a method of applying two tangential turning tools for turning down two diameters on a piece of work. This method is used when the distance *a* is not much greater than from ½ to ⅝ inch. If the distance *a* is much greater than this it is generally advisable to use two separate box-tools, that is, if there is sufficient room in the turret, although two turning tools can be set in the body of the holder, as will be explained later. When turning tools are used in this manner it is necessary to have the thickness of the first tool, or the distance *b*, such that the second tool when set tight up against the first one will turn the shoulder to the desired length.

To illustrate clearly how the distance *b* is obtained, we will take a practical example. Let $a = 0.375$ inch, $\beta = 10$ degrees; then $b = a \times \cos \beta = 0.375 \times 0.9848 = 0.3693$ inch. Where two turning tools are used in this manner they should be ground on all surfaces and should also be made a good fit in the square or oblong hole cut in the body of the holder to receive them.

Holding and Adjusting Box-tool Cutters

It is conducive to good results to have a box-tool cutter held rigidly in the holder, and not to project any further from the holder than is absolutely necessary to clear the largest diameter of the bar being turned. Means for adjusting the tool to cut different diameters should also be provided. At *A* in Fig. 3 is shown a method which is commonly used for holding a box-tool cutter for brass work. In this case a square hole is cut in the body of the holder to receive the cutter, the latter being held by a set-screw *a*. The cutter is adjusted for different diameters by the collar-head set-screw *b* which bears against the rear end of the tool. It is obvious

that this screw can only be used for adjusting the tool in, but by cutting a slot in the turning tool to fit the collar on the screw, this same screw may be used for adjusting the tool both in and out, thus making it more convenient.

The method of holding the turning tool shown at *B* is used particularly for brass work. In this case the turning tool is held in the block *c* by two set-screws *d*, the latter being adjusted in a slot along the body of the holder. The block or turning tool holder *c* has a projecting shank which passes through the body of the holder and is fastened to it by means of the nut and washer shown. It is evident that this method of holding the tool is very convenient for certain classes of work, especially when different diameters are required, as it is possible to have one or more blocks for holding the turning tools.

A method of adjusting and holding a tangential cutter is shown at *C*. Here, as can be seen, the cutter is set off at an angle from the face of the box-tool, and is held in the body of the holder by two set-screws *e* and *f*. The tool rests on a small block f_1, thus allowing it to be adjusted for turning different diameters, the two set-screws being used in connection with this block for adjusting. This method of adjusting and holding the turning tool is limited, very little adjustment being obtained by it.

A method of holding the turning tool somewhat similar to that just described is shown at *D*. Here the tool rests on the body of a screw *g* instead of a block. This screw is held in the holder as shown, and the tool is adjusted in a manner similar to that shown at *C*. The two previous methods of adjusting the tool are limited in their scope and, of course, can only be used for certain classes of work. A method which allows of more adjustment is shown at *E*. Here the tool is adjusted and held by three set-screws as shown, thus allowing the tool to be adjusted for various diameters, with the tool held in a plane parallel to the horizontal center line.

The methods shown at *C*, *D* and *E* are very seldom used for finishing box-tools, their use being principally for roughing box-tools. At *F* is shown a method of adjusting the turning tool holder which is usually applied to finishing box-tools. Here the tool is held in a block *h*, which is adjusted up and down on the body of the holder by means of the set-screw *i*, and is held when in the desired position by the cap-screw *j*. This block has a groove in it which fits on a tongue formed on the box-tool body, thus holding the tool-holder rigidly.

At *G* is shown a method similar to that just described, but the turning tool is in this case held in the holder in a manner similar to that shown at *C*. This provides means so that the cutter may be set at a slight angle from the horizontal center line, thus giving it more clearance, as is sometimes necessary, especially when cutting steel, and it also permits for a slight adjustment of the tool, independently of the tool-holder.

It will be seen from a study of the various methods previously shown that the setting of the tool cannot be accurately known, so that a number of trial cuts have to be taken before the desired diameter is obtained. To obviate this tedious operation of setting the tool, a micrometer screw is used for setting the box-tool cutter to the correct diameter, as shown at *H* and *I*. This micrometer screw *k* has two shoulders on it and is screwed into the body of the holder, the body of the screw being made a good fit in the block shown in detail at *I*. The hole in the block *l* through which the screw *k* passes is slotted out to the edge as shown, to facilitate assembling the screw in the block. A 40-pitch thread is cut on this screw, so that for one revolution of the screw the turning tool is moved up or down, as the case may be, a distance equal to 0.025 inch. By making this screw a good fit in the body of the holder and the block, it is possible to get the desired diameter without much trouble. The block is held to the body of the holder in the same manner as that shown at *F* and *G*.

A good method of holding two or more turning tools for roughing down work is shown at *J*, the holder, of course, being made with the desired amount of projecting lugs or toolholders *m*. The tool in this case is held in a stud *n*, which has a square hole cut in it to receive the turning tool. This hole is cut at an angle with the face, so that the tool is set at the desired angle. Two set-screws *o*, are used to prevent the tool from turning against the cut, and also to permit of a slight adjustment of the tool. As can be seen, this tool is limited in its scope, the changes for diameter being accomplished by means of the set-screws *o*, and also by moving the turning tool in or out a slight amount. This method of holding a turning tool is used mostly for roughing work and is applied in a manner similar to that shown at *E*, Fig. 2.

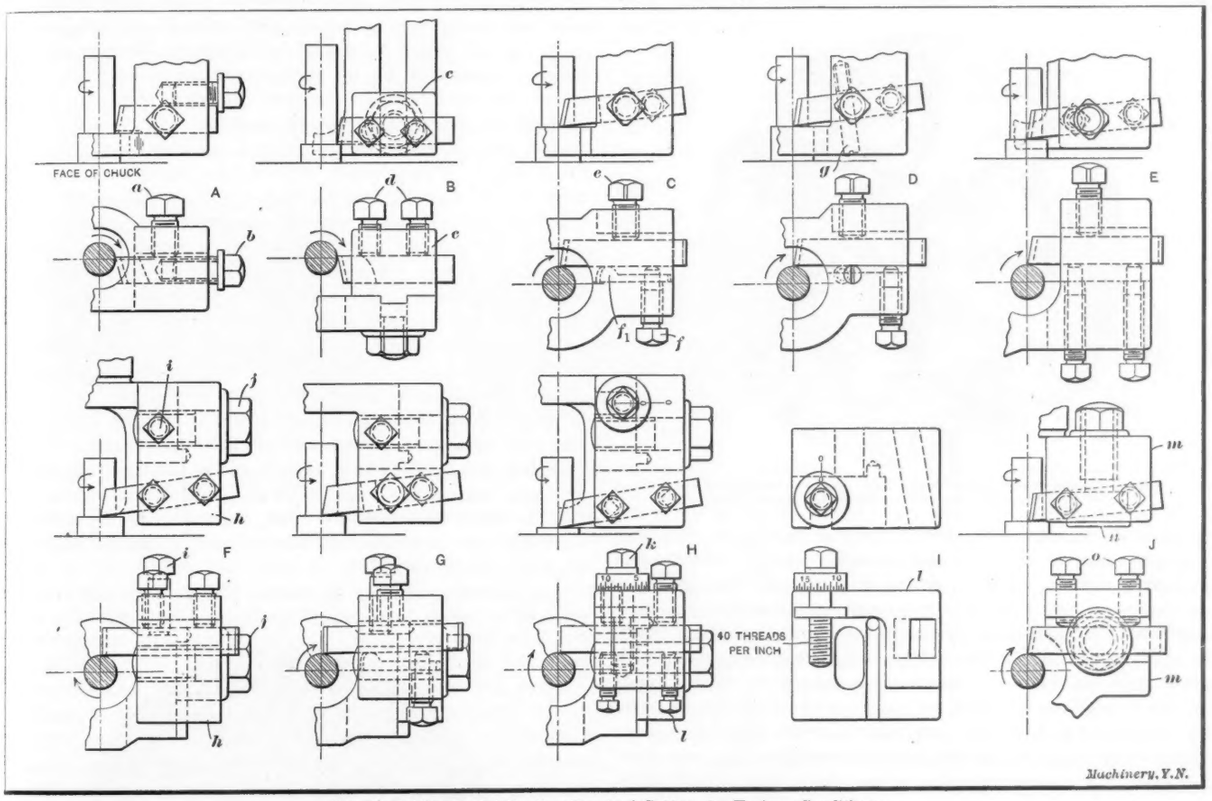


Fig. 3. Holding and Adjusting Box-tool Cutters for Various Conditions

THE FIELD FOR GRINDING*

By C. H. NORTON

Grinding in various forms has been known to man from the very beginning of history, yet it is doubtful if many engineers have a clear conception of the field for metal grinding. Experience (as a specialist) covering twenty-five years has taught me that the usual thought of grinding is that it is a slow, tedious, expensive, but sure method of obtaining accuracy, and that where great accuracy is not required grinding should not be done.

Webster defines abrasion as "the act of wearing or rubbing off; the wearing away by friction, as the abrasion of coins." Abrade, "to waste or wear away by friction, as to abrade rocks." He defines the word abraise as "rubbed smooth, as an abraised table," meaning a polished table. No doubt here is the connection between polishing and abrasion.

Some time within the last 75 to 100 years men discovered that a revolving polishing wheel enabled them to abrade work

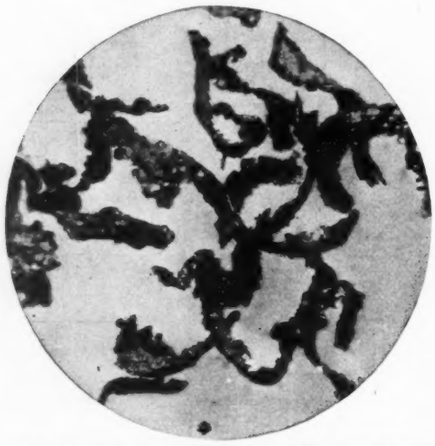


Fig. 1. Microphotograph of Chips from Modern Grinding Wheel, showing Resemblance of Fragments to Lathe Chips

in such a comparatively short time that so far as polishing was concerned it was no longer slow nor tedious. But as the original word for abrasive action was "grind," and grinding was slow, men still clung to the tradition in spite of the later discovery that polishing could be done quickly. When, within the recollection of the writer, mechanics made their own solid glue and emery wheels with which to grind small hardened tool work, it did not occur to them that they could do by grinding a certain part of the work that they were using steel tools for, because it was grinding, and was slow. Moreover, all nice work must, of necessity, take lots of time, because our older mechanics had said so. It did not occur to them that we could ever have better grinding wheels and better machines in which to use them. It was at this point in our reasoning that the majority of engineers rested and it is here that we find a large number now. All engineers admit the exactness of grinding, but most of them still believe it to be slow

Appleton's Cyclopedia of Applied Mechanics, published as late as 1893, says that emery wheels are employed mainly for producing cutting edges and for smoothing surfaces. Again, it says that in all cases of the employment of emery wheels in place of steel cutting tools, the operation is considerably slower, and it may be laid down as a rule that, save upon metal too hard to be operated upon with steel tools, the emery wheel cannot compete with the ordinary lathe, planer, milling tool, etc. My observations convince me that a great many American engineers hold the same views.

As a specialist for many years, I have seen a gradual but sure increase of knowledge of grinding and have noted the widening of the field as the result, but I am not aware that the intelligent study of grinding has been taken up by professional engineers or by any institute of technology. The intelligent use of grinding yields such large returns that it warrants careful study by the very best engineering and scientific minds and a place in the courses of our technical schools. The field is constantly broadening with each year's improvements in grinding wheels and grinding machines, and it is time that men of brains and education took a hand with us to help the world to a better knowledge of the science of grinding and grinding wheels.

The results thus far attained warrant a change of the world's idea of grinding and instead of using it as a synonym for slowness, tediousness and drudgery, it should be a synonym for rapidity, accuracy and economy.

The fact about grinding with the modern grinding machine and grinding wheel (not emery wheel) is that it enables us to size all round work cheaper than by turning and filing, that it takes the place of what we formerly called the finish cut of the lathe and all filing, giving us not a theoretically perfect cylinder or perfect finish, but a much nearer perfect cylinder and finish than we obtained with the lathe. It gives us diameters to such small limits as to be called exact, but whoever insists that none but exact work be ground loses the very pith of grinding, which is economy. Modern grinding means cheaper cost for all work, many grades of work to suit many requirements, and cheaper turning than is possible without the use of the grinding machine.

As a rule, the coarser the turning, the greater the economy by grinding. The greatest economy is obtained by the combination of cheaper turning and grinding. It is no longer necessary to turn work smooth, straight or correctly to size and the lathe is no longer necessary as a precision tool. If it has a carriage traverse of from four to ten threads per inch, has sufficient power to carry high-speed tool cuts at that feed and is well supplied with steadyrests to prevent springing of the work, it is ready for cooperation with the grinding machine. It is easier with modern grinding machines and wheels to grind off a given amount of metal when in the form of crude screw threads than in any other form, and with long work having several sizes, the grinding requires less time if 1/32 inch to 5/64 inch is left on the diameter for grinding than if the work is turned carefully to within 0.002 inch to 0.005 inch. In all cases, accurate turning increases the total cost of production and in some it makes the grinding very expensive.

The greatest economy is usually obtained by the combination of grinding with very rough turning. Yet there are

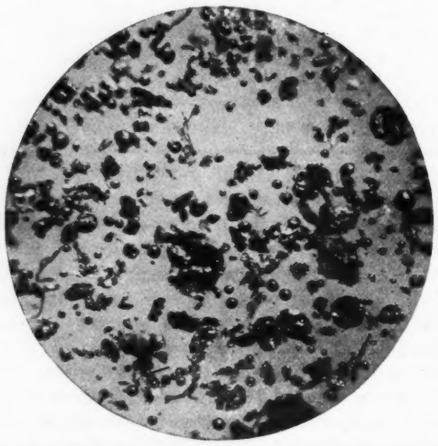


Fig. 2. Microphotograph of Fragments from Emery Wheel, emphasizing the Great Heat generated, which melts Particles

cases where the least expensive way is to grind direct without turning, notably the greater part of crankshafts of automobiles and small gas engines and very long and slender work where turning is difficult.

It is not an easy matter to secure such rough turning as true economy requires in connection with grinding. Lack of knowledge of what is needed, coupled with the natural pride the workman takes in doing what tradition says is nice lathe work, prevents the grinding machine from doing what it is ready to do. Our industries are losing much while waiting for the engineer to assume the intelligent guidance of

* Abstract of article read before the annual meeting of the American Society of Mechanical Engineers, New York, December, 1910.

foremen and workmen who, through fear, doubt or prejudice now rob us of the great economies due to modern grinding machines. There is much yet to be learned by foremen and workmen about turning. High-speed steel makes possible much that has not as yet become common knowledge.

The lathe is a very old tool and foremen and workmen have known it for generations, yet I have been unable to find more than two instances where a careful study has been made of the combination of lathe work and grinding to effect the maximum saving. I have observed that lathe men have not tried to remove metal by increasing the number of cuts and using fast traverse. When urged to take coarse feeds to help the grinding machine to effect a total saving, they have invariably said that they were feeding all that the work would stand. It has been demonstrated that three cuts with a carriage traverse of 6 per cent have produced certain work in 9 minutes that required 13 minutes to turn in one cut, because the work was so frail that with one cut no faster feed than 32 per inch could be taken. The rough-ridged surface was readily ground by taking 1 minute more than when the turning was finer, the net saving for the job being 3 minutes. In many cases the ridged surface requires no additional time.

In another case where the work was quite firm and was being revolved at a very high speed with a view to getting everything possible from the high-speed tool, the turning required 5 minutes and the grinding 1 minute. A change was made in the feed of the lathe so that without revolving the work any slower it was turned in 1 minute, leaving a very crude, crooked and bad-looking piece of lathe work. The grinding then required 2 minutes, but the net time saved was 3 minutes. Did it matter how bad a looking lathe job it was if the finished work was perfect and 3 minutes was saved?

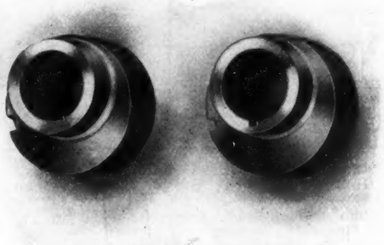
There is a rich field for engineers and managers in connection with the lathe and modern grinding. Recent lathe designs provide for high speed of revolution, with sufficient power, quick change to and from back-gears, and sufficient rigidity to utilize to the limit high-speed steel; but much work is not of sufficient rigidity to permit the maximum use of the tool at fast traverse and deep cuts. In addition, there are thousands of lathes of old design that will not be thrown away at once. There is, therefore, an opportunity to get much more out of present plants by cheaper turning, *because of grinding.*

Developments warrant the conclusion that we should no longer assume that simply because a tool is a grinding wheel it cannot remove metal, and size and shape work as quickly as a steel tool. Rather, we should use the steel tool when it can be made to remove metal, size and shape work cheaper, and the grinding wheel when it excels. It is no longer to be taken as a matter of course that we can turn, plane and mill faster than we can grind. After all, the real reason we remove metal is to accomplish certain finished results, not simply to secure a certain number of pounds of chips in a given time. Before long I think all progressive engineers will understand that both the grinding wheel and the steel tool have their place for metal cutting. The old thought of abrasion must give way to the new thought of cutting.

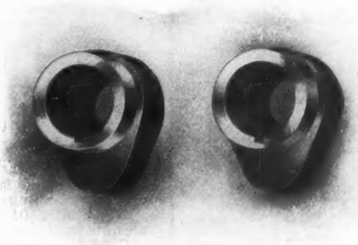
While it is still true that poor wheels or good wheels poorly selected and wrongly used will still remove metal very slowly by abrasion, it is also true that the old-fashioned milling cutter, with fine teeth cut by hand with a file, hardened but never ground, and used in the old-time slender milling machine would very slowly abrade the surface. The modern grinding wheel, used in a modern machine by a modern man, is just as surely a milling cutter as if it were made of steel. The microscope reveals the fact that such a wheel cuts off chips. Fig. 1 is from a microphotograph and clearly shows the chips that are as surely cut off as those made with a steel milling cutter. The grinding wheel used was a modern one made of crystalline aluminum oxide.

Fig. 2 is also from a microphotograph and shows the result of the old-fashioned abrasion described by Webster as "grinding to powder." Here we see the effect of great heat, the greater part of the powder being in the form of globules. This is magnified to the same extent as the other photograph and shows the vast difference between the old-time abrasion to powder and the present cutting of chips. A large part of the energy put into work was wasted in heat, as shown by the very small globules in Fig. 2. The wheel used for Fig. 2 was an emery wheel like those referred to in Appleton's cyclopedia of 1893.

The grinding wheel as now made is really a milling cutter with millions of cutting teeth. Although these teeth are not as large or as strong as the teeth of a steel cutter and therefore cannot cut as deeply, yet they are capable of cutting at much greater speed. Since there are so many more of them they are capable of much more work in a given time when the nature of the work is such that a large number of these cutting points can be used simultaneously. In some cases we can use as many as two billion cutting points per minute. Eight hundred million per minute is not uncommon and four hundred million per minute is very common.



Figs. 3 and 4. First Two Stages in the Grinding of an Automobile Cam



Figs. 5 and 6. Last Two Stages in the Grinding of an Automobile Cam

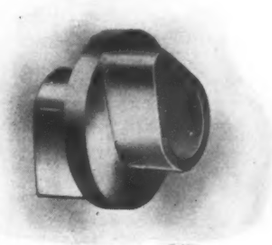


Fig. 7. Double Cam Ground from Rough Stock 2 inches in Diameter

The modern grinding wheel, mounted in a good machine, can be used at a cutting speed of 6000 or more surface feet per minute, and owing to this high speed it need not cut deeply relative to the rigidity of the work. Therefore it is able to remove metal from many forms of work more quickly than the milling cutter or the lathe tool.

The accompanying illustrations show a notable example. Figs. 3, 4, 5 and 6 show the process of making automobile cams. An order for a hundred of these cams was received and our shop superintendent began to provide means for producing them at the lowest possible cost. It is evident that drop forgings for so few would be out of the question, as the expense of dies would make the cost of the cams prohibitive. It was therefore necessary to devise means for producing them from the bar stock. This was done by providing an eccentric chuck for the automatic screw machine. To prevent the bar from turning in the chuck while feeding forward, the spline was made the full length and a mating key was placed in the chuck. Pieces like Fig. 3 were made in the automatic machine at the rate of 10 per hour. A keyway in the hole was made in the ordinary way, Fig. 4. These blanks were ground to rough shape, Fig. 5, at the rate of 10 per hour. The cams were then hardened and finish-ground, Fig. 6, at the rate of 40 per hour. It should be clear that such a cam could not be milled to shape from the blank in nearly so short a time with the milling cutter. When manufacturing such cams in large numbers, drop forgings would be used, and here again the grinding wheel is quicker than the milling cutter.

Another case where the grinding machine can accomplish the results desired in less time than the lathe is that of the pins and bearings of the automobile crankshaft. The results

desired are as follows: Five bearings, all round within 0.00025 inch, the axis of all, parallel and exactly in line; all of the right length within 0.004 inch; distance between bearings within 0.004 inch; accumulated error not over 0.008 inch. Four crankpins, all round within 0.00025 inch; the axis of all exactly parallel; all to length within 0.004 inch; all parallel with the bearings; all within 0.005 inch of the same plane; all of correct throw, within 0.010 inch; over-all length, accumulated error not over 0.008 inch; all fillets correct radius and exactly concentric with the bearings and pins; all bearings and pins straight within 0.00025 inch; and all a good, smooth surface.

In the case of cranks designed with clearance for the arms of the cranks, as shown in Fig. 8, the width of the wheel is identical with the required length of the pins and bearings, so that no measuring or setting of the tool is necessary for cutting to length. The act of grinding cuts the bearing or pin the right length and forms the fillets. The location of the pins and bearings within the small limits allowed is accomplished by a massive index bar, so that the workman does

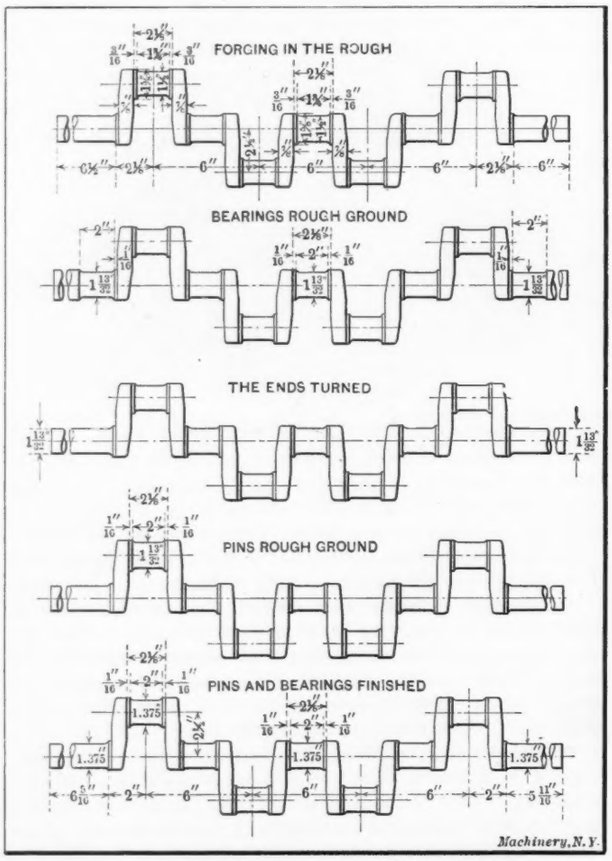


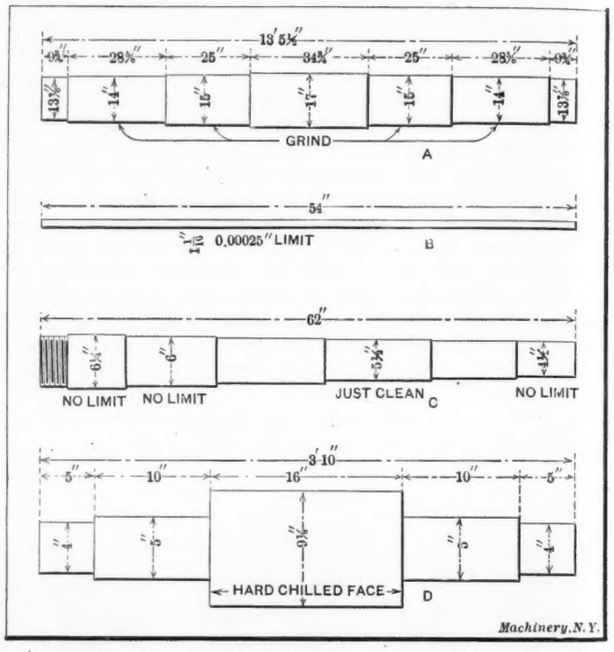
Fig. 8. Stages in the Grinding of an Automobile Crankshaft

no measuring whatever for location of bearings or pins. The entire time of handling and producing these five bearings and four pins from the rough forging to the nicely-sized and finished condition is 85 minutes. It is clear that when all the conditions of the finished work are considered the grinding wheel and machine have removed metal faster than the lathe. Again, it is not simply a case of removing pounds of metal per hour, but the removal of it in such a manner as to accomplish certain results in the least time.

The ends of these shafts beyond the bearings are turned before grinding. The entire list of operations to make a finished shaft from the forging is as follows:

Cut off ends and center	6 minutes
Rough-grind bearings	15 minutes
Turn ends	8 minutes
Rough-grind pins	20 minutes
Finish-grind pins	20 minutes
Finish-grind bearings and ends	25 minutes
Square ends	6 minutes
Total time	100 minutes

A little time could be saved if it were practical to secure forgings with pins and bearings 1⅝ inch in diameter over their entire length instead of with the depression to 1¼ inch between shoulders, as the wheel can be forced more rapidly when the face has the same amount of work to do as the fillets. Here, again, tradition is strong and difficult to change



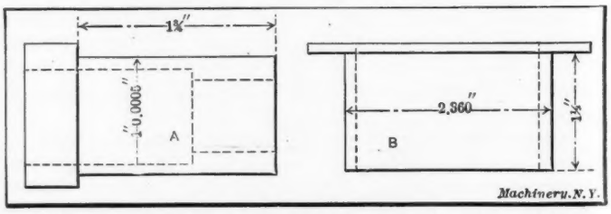
A.—Engine shaft, hammered forging. Weight 8000 pounds; stock removed, 0.025 inch; limit, 0.001 inch; time, 6 hours (8 hours including handling.)
B.—Shaft, 0.30 carbon steel. Stock removed, 1/16 inch; limit, as noted; time, 1 hour (including setting up.)
C.—Lathe spindle, crucible steel, hardened. Stock removed, 0.035 inch; limits, as noted; time, 1½ piece per hour.
D.—Chilled roll, chilled iron. Stock removed, ⅝ inch; time to roll face, 2½ hours; previous lathe time, 12 hours.

Fig. 9. Examples of Grinding on Long Work

at once, because the depression is better for those who turn the work. A little cooperation on dies would save time in grinding.

There are hundreds of other cases where the grinding wheel is used to remove metal in a more economical manner than with steel cutting tools, some of which are shown in Figs. 9 and 10.

Automatic grinding is a late development in the field. Certain work of which large numbers of pieces are made is ground by wholly automatic means. The work is conveyed to the machine by gravity in a hopper or chute and is chucked, ground and delivered to the receptacle. In a case where



A.—Bushing, cast iron. Stock removed, 0.010 inch; limit, as noted; time, 45 pieces per hour.
B.—Bushing, pressed steel. Stock removed, 0.025 inch; limit, 0.0005 inch; time, 60 pieces per hour.

Fig. 10. Rapid Production on Bushings

formerly, at piece work, 300 per day were ground, the automatic machine grinds 4 in a single minute—about 2300 per day.

When the knowledge of grinding becomes more common and the opposition to increased production on the part of the workmen shall have been more nearly overcome, the field will be still more extended. It is worthy of more systematic cooperation and if we get together we will be rewarded with success. The engineer is the one who by education and training is best fitted to take up the important question of the field for grinding.

PRECISION GRINDING*

By W. A. VIALL

Grinding is an art rather than an exact mechanical operation. It is an art of such recent growth that relatively little is known about it or its possibilities. In the development of the grinding machine from the beginning, as described in the historical article in MACHINERY of July, 1910, to the present well-known makes of universal and plain grinding machines, the successive steps that have been taken toward reaching stability and convenience in the machine form interesting chapters of mechanical history, since they show, as well as any class of machines, the tendency of the times.

In speaking of grinding as an art I mean that it contains elements in which the judgment and experience of the operator count for a great deal. While in a general way the manufacturer or the skilled operator is able to give instructions for the running of the machines, yet conditions arise which make it necessary to vary from these instructions in order to obtain the best results. To instruct an operator to use a given wheel and speed would make it possible for him to obtain any one of three results: When ground with a wheel surface that is not true a piece looks as though it had been gouged upon a grindstone, while with a wheel surface that is true it gives a dull finish and shows wheel marks. The latter is what we consider commercial grinding. When the same wheel has been run so that the points of the abrasive become somewhat dull, we obtain a highly-finished surface. All these results are possible with the same wheel under different conditions.

TABLE I. GRINDING LIMITS FOR CYLINDRICAL PIECES*

As adopted by Brown & Sharpe Mfg. Co.

RUNNING FITS—ORDINARY SPEED			
To ½-in. diameter, inc.	0.00025 to 0.00075		Small
To 1 -in. diameter, inc.	0.00075 to 0.0015		Small
To 2 -in. diameter, inc.	0.0015 to 0.0025		Small
To 3½-in. diameter, inc.	0.0025 to 0.0035		Small
To 6 -in. diameter, inc.	0.0035 to 0.005		Small
RUNNING FITS—HIGH SPEED, HEAVY PRESSURE AND ROCKER SHAFTS			
To ½-in. diameter, inc.	0.0005 to 0.001		Small
To 1 -in. diameter, inc.	0.001 to 0.002		Small
To 2 -in. diameter, inc.	0.002 to 0.003		Small
To 3½-in. diameter, inc.	0.003 to 0.0045		Small
To 6 -in. diameter, inc.	0.0045 to 0.0065		Small
SLIDING FITS			
To ½-in. diameter, inc.	0.00025 to 0.0005		Small
To 1 -in. diameter, inc.	0.0005 to 0.001		Small
To 2 -in. diameter, inc.	0.001 to 0.002		Small
To 3½-in. diameter, inc.	0.002 to 0.0035		Small
To 6 -in. diameter, inc.	0.003 to 0.005		Small
STANDARD FITS			
To ½-in. diameter, inc.	Standard to 0.00025		Small
To 1 -in. diameter, inc.	Standard to 0.0005		Small
To 2 -in. diameter, inc.	Standard to 0.001		Small
To 3½-in. diameter, inc.	Standard to 0.0015		Small
To 6 -in. diameter, inc.	Standard to 0.002		Small
DRIVING FITS—FOR SUCH PIECES AS ARE REQUIRED TO BE READILY TAKEN APART			
To ½-in. diameter, inc.	Standard to 0.00025		Large
To 1 -in. diameter, inc.	0.00025 to 0.0005		Large
To 2 -in. diameter, inc.	0.0005 to 0.00075		Large
To 3½-in. diameter, inc.	0.00075 to 0.001		Large
To 6 -in. diameter, inc.	0.001 to 0.0015		Large
To ½-in. diameter, inc.	0.0005 to 0.001		Large
DRIVING FITS			
To 1 -in. diameter, inc.	0.001 to 0.002		Large
To 2 -in. diameter, inc.	0.002 to 0.003		Large
To 3½-in. diameter, inc.	0.003 to 0.004		Large
To 6 -in. diameter, inc.	0.004 to 0.005		Large
To ½-in. diameter, inc.	0.00075 to 0.0015		Large
FORCING FITS			
To 1 -in. diameter, inc.	0.0015 to 0.0025		Large
To 2 -in. diameter, inc.	0.0025 to 0.004		Large
To 3½-in. diameter inc.	0.004 to 0.006		Large
To 6 -in. diameter, inc.	0.006 to 0.009		Large
To ½-in. diameter, inc.	0.00025 to 0.0005		Large
SHRINKING FITS—FOR PIECES TO TAKE HARDENED SHELLS ⅜-IN. THICK AND LESS			
To 1 -in. diameter, inc.	0.0005 to 0.001		Large
To 2 -in. diameter, inc.	0.001 to 0.0015		Large
To 3½-in. diameter, inc.	0.0015 to 0.002		Large
To 6 -in. diameter, inc.	0.002 to 0.003		Large
To ½-in. diameter inc.	0.0005 to 0.001		Large
SHRINKING FITS—FOR PIECES TO TAKE SHELLS, ETC., HAVING A THICKNESS OF MORE THAN ⅜-IN.			
To 1 -in. diameter, inc.	0.001 to 0.0025		Large
To 2 -in. diameter, inc.	0.0025 to 0.0035		Large
To 3½-in. diameter, inc.	0.0035 to 0.005		Large
To 6 -in. diameter, inc.	0.005 to 0.007		Large
To ½-in. diameter, inc.	Standard to 0.0005		Large
GRINDING LIMITS FOR HOLES			
To 1 -in. diameter, inc.	Standard to 0.00075		Large
To 2 -in. diameter, inc.	Standard to 0.001		Large
To 3½-in. diameter, inc.	Standard to 0.0015		Large
To 6 -in. diameter, inc.	Standard to 0.002		Large
To 12 -in. diameter, inc.	Standard to 0.0025		Large

* The limits given in the table can be recommended for use in the manufacture of machine parts to produce satisfactory commercial work. These limits should be followed under ordinary conditions. For special cases, it may be desirable to vary slightly from the tables.

Most of us are interested in two classes of grinding. One is the occasional grinding such as we find in the tool-room and in the shop where one or two pieces of a kind are made and where accurate fits are demanded. The second is the manufacturer's problem where not only must the nicest accuracy be obtained but where the rate of production is an important consideration. In the first case the question of cost does not enter so deeply into the problem, although it is always to be considered; and one machine, specially designed to do a certain class of work, is often compelled to answer the necessities for work to which it is not well suited. In the second case, however, the best results as to efficiency and production are obtained by having a machine of the proper size. It must be understood from the first that whether the machine is large or small it must be sufficiently heavy and stable enough to do the work it is called upon to do and it must be so designed that it can readily be operated. This latter element of convenience must be provided for even more carefully than in many other classes of tools, because much of the work done in the grinding machine is of such a character that the operations of putting in and taking out consume almost as much time as the grinding. Moreover, a grinding machine must have sufficient rigidity to preserve its alignment, which must be of a high grade from the first. Unless the machine is capable of producing true work its value is lost, for the grinding machine must not only finish work but also rectify it to a degree of accuracy that we cannot, in reason, look to a lathe or other type of machine to furnish commercially.

TABLE II. LIMIT GAGES FOR LATHE WORK

Size	Not Go On	Go On	Size	Not Go On	Go On
	Inches			Inches	
$\frac{3}{8}$	0.383	0.387	$1\frac{1}{4}$	1.258	1.262
$\frac{7}{16}$	0.4455	0.4495	$1\frac{5}{16}$	1.3205	1.3245
$\frac{1}{2}$	0.508	0.512	$1\frac{3}{8}$	1.383	1.387
$\frac{9}{16}$	0.5705	0.5745	$1\frac{7}{16}$	1.4455	1.4495
$\frac{5}{8}$	0.633	0.637	$1\frac{1}{2}$	1.508	1.512
$\frac{11}{16}$	0.6955	0.6995	$1\frac{9}{16}$	1.5705	1.5745
$\frac{3}{4}$	0.758	0.762	$1\frac{5}{8}$	1.633	1.637
$\frac{13}{16}$	0.8205	0.8245	$1\frac{11}{16}$	1.6955	1.6995
$\frac{7}{8}$	0.883	0.887	$1\frac{3}{4}$	1.758	1.762
$\frac{15}{16}$	0.9455	0.9495	$1\frac{13}{16}$	1.8205	1.8245
1	1.008	1.012	$1\frac{7}{8}$	1.883	1.887
$1\frac{1}{16}$	1.0705	1.0745	$1\frac{15}{16}$	1.9455	1.9495
$1\frac{1}{8}$	1.133	1.137	2	2.008	2.012
$1\frac{3}{16}$	1.1955	1.1995	...	.....	.....

For illustration see Fig. 1.

The principles of grinding, in the main, are not difficult to grasp, and the time that would be required of the ordinary chief operator in grasping them is not excessive. But the work does require such attention and knowledge of the results that can be obtained, coupled with the skill acquired by experience, as to class it with the arts. In the early days it seemed quite necessary that for every different piece of work we should have a different wheel. Later it was found that a given wheel would give satisfactory results on various kinds of work by varying the speed of the wheel, the speed at which the work was run, or the feed of the work, so that one wheel answered a great variety of purposes. There have been changes in abrasives and we are getting today a far better quality of wheel than was possible some years ago. The grading of wheels has very much improved, and although in the writer's opinion it is not possible to obtain an absolute grading, this element has been reduced to such a nicety that it need not be taken largely into account.

The first use of the grinding machine as we know it today was to correct slight errors that were impossible of eradication by means of the file and emery cloth. Today the

* Abstract of paper read before the annual meeting of the American Society of Mechanical Engineers, New York, December, 1910.

grinding machine rectifies these errors and in addition finishes work for appearance and fit in a relatively cheap manner.

After the proper machine has been selected, the choice of wheels requires some specialized knowledge which the makers of machines and wheels are in a position to furnish to an extent that many of the users of machine tools are probably not aware of. When the proper wheels and gradings are once established for a given line of work, their subsequent use is very easy.

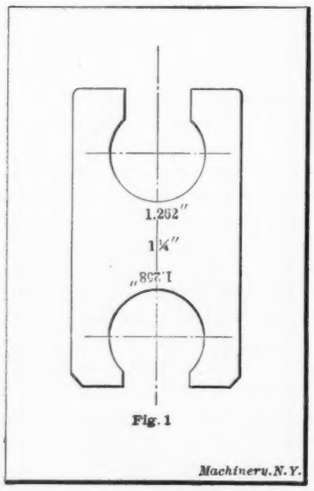
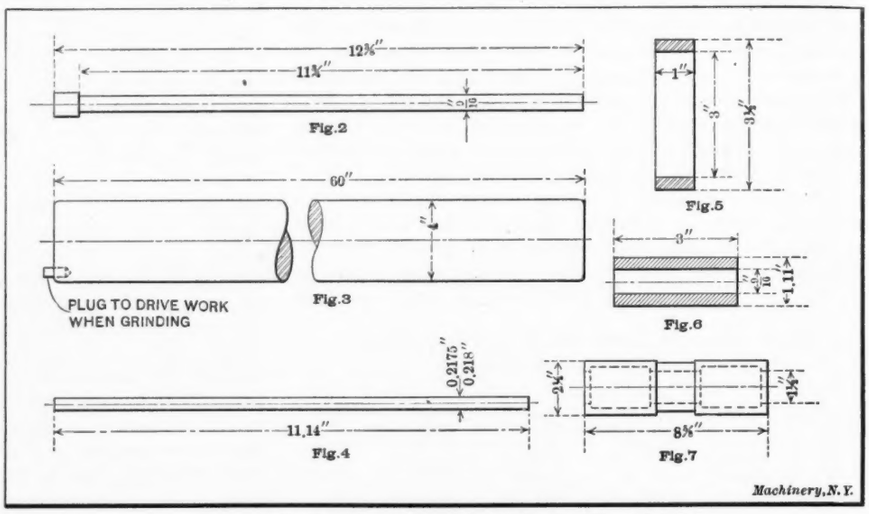


Fig. 1. Type of Limit Gage used. See Table II



Figs. 2 to 7. Some Varied Examples of Grinding Work detailed in the Table below

American Machinist, July 2, 1903, where the microscopic photographs showed that the chips somewhat resembled those made by a lathe tool. It is only under proper conditions, however, that these results can be obtained. The wheels must be true and they must not be forced into the work to too great an extent, for this produces a torn effect upon the work, which is to be avoided.

In considering a piece of work to be done, first of all the question arises as to the size and the limits suitable for the purpose for which it is intended. Table I gives the limits used at the Brown & Sharpe Mfg. Co.'s works for varying conditions. There are special cases where it may be necessary to increase or to decrease these limits, and this table is not offered as the final word but as a guide towards selection.

Fig. No.	2	3	4	5	6	7
Material	Soft machinery steel	Machinery steel	Machinery steel, casehardened	Machinery steel, casehardened	Cast iron	Bearing bronze
Part Ground	External	External	External	Internal	External	External
Machine Used	No. 11 Plain	No. 28 Plain	No. 11 Plain	No. 1 Universal (special)	No. 11 Plain	No. 14 Plain
Wheel Used	Monarch, 12 in. × 1 in. Corundum, No. 46, grade 2½	Norton, 24 in. × 2 in. Alundum, No. 3846, grade K	Norton, 12 in. × ½ in. Alundum, No. 36, grade 5, elastic	Norton, 2½ in. × 2 in. Alundum, No. 5, grade 2½, elastic	American, 12 in. × 1 in. Corundum, No. 46, grade K	Abrasive, 18 in. × 1½ in. Corundum, No 60, grade L
Periphery Speed of Work, Ft. per Min.	35	35 roughing; 60 finishing	35	100	55	75
Travel of Work, In. per Min.	96	48 roughing; 30 finishing	13	By hand	37	30
Periphery Speed of Wheel, Ft. per Min.	7000	6000	5500 to 6000	5500	6500	6000
Amount of Stock Removed, Diameter	0.012 in. roughing, 0.005 in. finishing	0.025 in. roughing 0.005 in. finishing	0.005 in. roughing; 0.001 in. finishing	0.018 in. to 0.020 in. | 0.010 in. to 0.010 in.	0.020 in. to 0.025 in.	0.012 in. to 0.015 in.
Number of Pieces Completed per Hr.	13	3.5	15	16 | 20	54	32 1 man | 59 2 men*
Required Limit	Standard to 0.00025 in. small	Standard to 0.001 in. small	Standard to 0.0005 in. small	Standard to 0.0005 in. large	Standard to 0.0005 in. small	Standard to 0.0005 in. small
In Lots of	100	50	500	200	200	100
Remarks	21 roughed; 35 finished per hr. Handled twice	7 roughed; 7 finished per hr. Handled twice	Handled twice for roughing and twice for finishing			*A man operates the machine and a helper puts the work on and off the arbor.

Fig. No. 2 — Material: Soft machinery steel — Part Ground: External — Machine Used: No. 11 Plain — Wheel Used: Monarch, 12 in. × 1 in. Corundum, No. 46, grade 2½ — Periphery Speed of Work, Ft. per Min.: 35 — Travel of Work, In. per Min.: 96 — Periphery Speed of Wheel, Ft. per Min.: 7000 — Amount of Stock Removed, Diameter: 0.012 in. roughing, 0.005 in. finishing — Number of Pieces Completed per Hr.: 13 — Required Limit: Standard to 0.00025 in. small — In Lots of: 100 — Remarks: 21 roughed; 35 finished per hr. Handled twice

Fig. No. 3 — Material: Machinery steel — Part Ground: External — Machine Used: No. 28 Plain — Wheel Used: Norton, 24 in. × 2 in. Alundum, No. 3846, grade K — Periphery Speed of Work, Ft. per Min.: 35 roughing; 60 finishing — Travel of Work, In. per Min.: 48 roughing; 30 finishing — Periphery Speed of Wheel, Ft. per Min.: 6000 — Amount of Stock Removed, Diameter: 0.025 in. roughing 0.005 in. finishing — Number of Pieces Completed per Hr.: 3.5 — Required Limit: Standard to 0.001 in. small — In Lots of: 50 — Remarks: 7 roughed; 7 finished per hr. Handled twice

Fig. No. 4 — Material: Machinery steel, casehardened — Part Ground: External — Machine Used: No. 11 Plain — Wheel Used: Norton, 12 in. × ½ in. Alundum, No. 36, grade 5, elastic — Periphery Speed of Work, Ft. per Min.: 35 — Travel of Work, In. per Min.: 13 — Periphery Speed of Wheel, Ft. per Min.: 5500 to 6000 — Amount of Stock Removed, Diameter: 0.005 in. roughing; 0.001 in. finishing — Number of Pieces Completed per Hr.: 15 — Required Limit: Standard to 0.0005 in. small — In Lots of: 500 — Remarks: Handled twice for roughing and twice for finishing

Fig. No. 5 — Material: Machinery steel, casehardened — Part Ground: Internal — Machine Used: No. 1 Universal (special) — Wheel Used: Norton, 2½ in. × 2 in. Alundum, No. 5, grade 2½, elastic — Periphery Speed of Work, Ft. per Min.: 100 — Travel of Work, In. per Min.: By hand — Periphery Speed of Wheel, Ft. per Min.: 5500 — Amount of Stock Removed, Diameter: 0.018 in. to 0.020 in. \| 0.010 in. to 0.010 in. — Number of Pieces Completed per Hr.: 16 \| 20 — Required Limit: Standard to 0.0005 in. large — In Lots of: 200

Fig. No. 6 — Material: Cast iron — Part Ground: External — Machine Used: No. 11 Plain — Wheel Used: American, 12 in. × 1 in. Corundum, No. 46, grade K — Periphery Speed of Work, Ft. per Min.: 55 — Travel of Work, In. per Min.: 37 — Periphery Speed of Wheel, Ft. per Min.: 6500 — Amount of Stock Removed, Diameter: 0.020 in. to 0.025 in. — Number of Pieces Completed per Hr.: 54 — Required Limit: Standard to 0.0005 in. small — In Lots of: 200

Fig. No. 7 — Material: Bearing bronze — Part Ground: External — Machine Used: No. 14 Plain — Wheel Used: Abrasive, 18 in. × 1½ in. Corundum, No 60, grade L — Periphery Speed of Work, Ft. per Min.: 75 — Travel of Work, In. per Min.: 30 — Periphery Speed of Wheel, Ft. per Min.: 6000 — Amount of Stock Removed, Diameter: 0.012 in. to 0.015 in. — Number of Pieces Completed per Hr.: 32 1 man \| 59 2 men* — Required Limit: Standard to 0.0005 in. small — In Lots of: 100 — Remarks: *A man operates the machine and a helper puts the work on and off the arbor.

The question of speeds and feeds is also the result of experience, and suggestions from the manufacturers will help users to a great extent in obtaining satisfactory results. The cutting operation of the wheel was well shown in an illustrated article by Messrs. Gribben and Warman in the *Ameri-*

The second necessity is that sizes should be established to

which the work should be rough turned ready for the grinding room. In our works, as in all factories, the aim is to produce the desired results as cheaply as possible. Our desired ends have been accuracy and nicety of finish where the parts ground are for fits, and nicety of finish where no fit is required. To do this work as cheaply as possible we believe that it is economical to turn the pieces to about the sizes indicated in Table II. It will be noted that we allow from 0.008 inch to 0.012 inch in diameter, an amount easily obtained by the ordinary class of lathe help. In order to make this work as easy as possible for the lathe department, we furnish the limit gage shown in Fig. 1. We are aware that practice varies on this point, and we have thoroughly endeavored to try out the plan of allowing correct limits, but we have found it fully practicable to hold the lathe to the limits given. By so doing we obtain the finished product free from all tool marks and at what we believe is the minimum cost.

Figs. 2 to 7 show some samples of commercial grinding taken from actual practice for the purpose of giving an idea of what can be done in a commercial way, as well as to give some definite data as to speeds, feeds, etc. While it is perhaps not possible to give a rule that will fit all work, these engravings should suggest ideas that will help in producing the work as well and as cheaply as this has been done in the cases shown. When enough pieces of any one kind are to be made it is possible to specialize to a higher degree than can be done in the general run of work, and better results may be obtained than are shown here.

The examples of commercial grinding given in Figs. 2 to 7 illustrate what is being done under actual working conditions in commercial work on the variety of pieces indicated, which are of various materials, both soft and hard. A reversal of the usual rule, where economy is gained by having one man operate more than one machine, is shown in Fig. 7, where the work is most economically produced by using two men to run one machine, that is, having one man to operate it and a helper to drive the work on and off the arbor. All other data are based on one man to a machine.

These pieces passed inspection within the limits given. The average loss from work of this class coming below the required limit or being otherwise spoiled is less than ¼ of 1 per cent in our grinding department.

* * *

REPAIRING JOURNAL OF A DIRECT-CONNECTED GENERATOR

By OBSERVER

While visiting a power house in one of the western mining regions the writer came across a very interesting repair job, which he considers will be of interest to some readers of

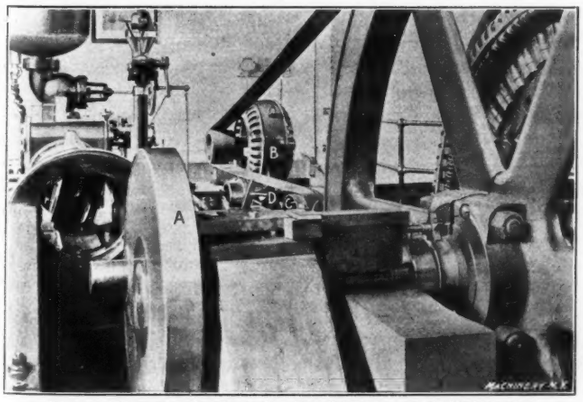


Fig. 1. View showing how the Small Motor was belted to the Large Flywheel

MACHINERY. The illustrations, Figs. 1 and 2, show the method that was used in repairing the main journal of a direct-connected electric generator. This journal was 12 inches in diameter by 18 inches long, and was situated in the rear of the crank-disk shown at *A* in the illustrations. This journal had run hot, and was badly scored for its entire length. Now to take the shaft out would have caused considerable delay, and there were also no facilities at hand for handling such a heavy job, so it was decided to true up the journal without removing it.

To true up the journal, a belt was run over the flywheel, and connected to a small motor *B* (Fig. 1) which was brought into service. An idler *C*, which can be seen close to the large flywheel, was used to overcome the small contact of the belt on the flywheel, and also to give the belt more pulling power. The manner in which the journal was turned is as follows: After disconnecting the main-rod, etc., the eccentric cams were removed and a piece of oak timber, which had previously been bored out, was babbitted and then rebored to the same radius as the journal. This support was then held tight up against the journal by means of other timbers

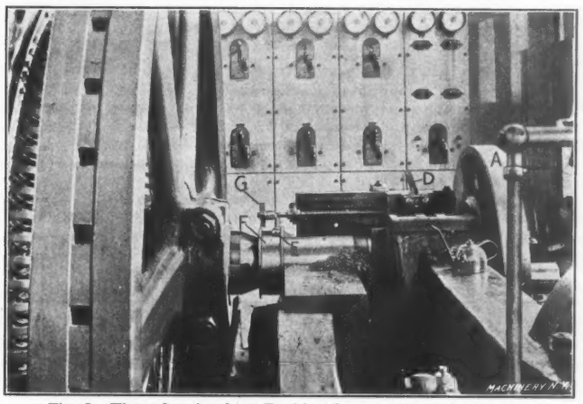


Fig. 2. View showing how Tool-head was utilized for Turning the Scored Journal

which were supported in various positions, and every precaution was taken to prevent any lateral movement of this "impoverished" journal. The pedestal, cap and other sections of the shaft bearing were removed, and a tool-head was then taken from a large planer, which with the addition of a few clamping devices was held in position as shown in Fig. 2. A one-inch square turning tool *D* was then fastened in the tool-rest and brought into a central position with the journal. A small finger *E* was then secured to the rim of the governor pulley, *F*, which operated a star wheel *G*, used in feeding the tool across the work. The journal which was turned is behind the bracket, and it is impossible to see it in the illustrations.

After turning the journal by the method shown, a lead lap was made and the journal was allowed to run in it for a period of about one hour. The cap and other parts of the bearing were then rebabbitted and bored out to fit the diameter to which the journal had been turned. This job was found to be very satisfactory, and, considering everything, comparatively little delay was caused. The writer has since learned that the engine in question has been running satisfactorily for several months.

* * *

SOFTENING RUST

A recent issue of the *Brass World* contained a simple method for removing rust from surfaces that were afterwards to be electro-plated, but the method might be applied equally well to other rusty surfaces. It consists in dipping the articles first into a strong hot potash bath for about half an hour, and then immersing in a cold muriatic acid pickling solution, composed of two parts of water to one of acid. This removed the rust in a few minutes, leaving the metal apparently attacked but very little. The previous soaking in the strong hot potash solution is responsible for this rapid pickling, as a test proved, for without the previous dipping, sixty-five minutes was required by the acid bath, against four minutes when previously treated in the potash bath. Apparently a chemical reaction is set up, changing the character of the rust, softening it and making it readily soluble. The appearance of the rust as it comes from the potash kettle testifies to this, as it is black and soft, and may almost be rubbed off with the hand. The pieces that have been treated in the potash bath have a smooth and glossy finish

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MACHINERY

DESIGN—CONSTRUCTION—OPERATION

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JANUARY, 1911

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MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition, $1.00 a year, which comprises approximately 700 reading pages and 36 Shop Operation Sheets, containing step-by-step illustrated directions for performing 36 different shop operations. The Engineering Edition—$2.00 a year, coated paper $2.50—contains all the matter in the Shop Edition, including Shop Operation Sheets, about 300 pages a year of additional matter and forty-eight 6 x 9 Data Sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. The Railway Edition, $2.00 a year, is a special edition including a variety of matter for railway shop work—same size as Engineering and same number of Data Sheets.

THE DIE-CASTING ART

Although die-casting—the forming of shapes by casting in metal molds—is one of the old arts, having been employed for making type, bullets, etc., for many years, it is nevertheless one of the new arts as applied to the commercial production of parts that require cheap and accurate formation. The field of die-casting is large and is growing. Parts of typewriters, adding and computing machines, cash registers, electrical apparatus, speedometers, etc., are die-cast in "white brass" at very low cost and true to pattern within one-thousandth inch or less.

The drawbacks to the process are the cost of dies, which usually makes the price prohibitive for a small number of parts, and the cost of the metal. The latter runs directly proportional to the number of parts, while the former is inversely proportional to the number, becoming so small for a large number as to be insignificant. The metal cost of small parts, however, is low when the high cost of machining cheaper metals that cannot be die-cast, is considered.

Die-casting is likely to become of much greater importance relatively to other means of shaping metal machine parts than now, especially if the more refractory metals can be die-cast. Cast-iron pipe and fittings are now successfully cast in metal molds, the molding in sand being, of course, eliminated, with consequent saving of labor. The possibility of very largely cutting out machine work on cast-iron parts is rather startling to those of us who regard the present order of procedure in manufacturing machinery as unalterably fixed. There seems to be little probability of any great change in the immediate future, but the possibility of revolutionary methods of this character being fully developed in the next twenty years is something to be considered by the builders of machine tools. If such development does take place, it will mean that the growth of the industry will not run parallel to the growth of general manufacturing, but will lag behind. The cheapening of machinery cost would tend, however, to stimulate manufacturing generally; and so, while machine tools might not be directly employed in the manufacture of machinery as much, relatively, as now, they would still be required in great numbers for mold making and other operations incident to the production of cast-iron parts. Of course, the machining of forged, drawn and rolled stock would not be affected by the change.

* * *

PROFITABLE EMPLOYMENT OF MACHINERY

The ideal condition in a manufacturing business is that in which the productive capacity is always at the highest point of efficiency consistent with a first-class product. Naturally those investments which apparently do not yield a constant income are looked upon with disfavor. For example, a machine that cannot be run every day is likely to become an eyesore if it cost several thousand dollars and stands in a conspicuous place. It may be that the character of work done on the machine is such that it could not be done on any other in the plant, nor could the work be done at a reasonable price elsewhere, but the stigma of unprofitable investment may nevertheless be set upon the idle tool, and someone responsible for its purchase is likely to be made uncomfortable by those interested solely in the financial side of the enterprise.

The theory that every machine should be worked all the time is sound, but its practice should not be allowed to deprive the plant of those machines which, though unprofitable, perhaps, in direct production, so facilitate the production that they are indirectly indispensable.

In the case of farm machinery, we probably have the extreme of idle or non-productive period in the year, as compared to the actual working time. The farmer's investment in agricultural tools is relatively large, and the period of actual use during the year is very short. For example, a harvester costing $150 may be used only ten or twelve days in the year; but, in that time it does the work of ten men working with the primitive hand implements in vogue before harvesting machinery was introduced. The returns on the investment are large, and though his machinery is in use so short a time, the farmer could not profitably plant and harvest his crops without it.

This extreme condition of long idle period but profitable investment, and that of actually unprofitable investment in a well-nigh indispensable machine are widely separated; so widely, in fact, that it may be set down as a principle that the well-nigh indispensable machine cannot be unprofitable in itself if the business as a whole is prosperous and its continuance depends upon the performance of that machinery.

* * *

THE STRENGTH OF MACHINE PARTS

Some mechanics think that a machine part which does not break when in use is amply strong. In many types of machinery, however, especially in machines performing operations requiring considerable precision—whether they are machine tools, printing presses, match-box machinery or other kinds—the mere fact that a machine detail does not break is not a sure indication that it has the required strength to serve its proper function. In most machinery of this type any springing action of the parts is almost as objectionable as actual breakage. If a part springs out of shape because it is not as strong as it should be, the work performed by the machine probably will be inaccurate, and the value of the whole machine will be affected merely on account of the lack of strength of a single detail. In fact, a machine detail which springs out of shape, while in action, is often more objectionable than one that actually breaks under the stress, because in the former case it may be very difficult to locate the cause of the trouble, whereas if the part breaks the weakness is at once located, and it can be effectually remedied with comparatively little trouble.

Another difficulty sometimes met with in the operation of machinery is that certain parts are out of proportion to others. Some parts may be excessively heavy and impose stresses on others which are unnecessary and could easily have been avoided. The latter parts may have ample strength

for the functions they were intended to perform, but, on account of the improper design of some other part, they cannot do their work properly. In one case that has come within the writer's experience, a machine table on which a slide was mounted was sprung out of shape so badly by attaching a heavy gear box to the overhanging end of the table, that the slide became locked in its ways and refused to move. With the gear-box supported from the column of the machine, the difficulty was wholly avoided. The greatest care should be taken to produce a harmonious design in which all parts are proportioned with reference to each other; and in particular should it be remembered that the parts must not only be strong enough to resist breakage, but of ample proportions so that no objectionable springing action will appear when the machine is in operation.

* * *

PRACTICAL COST REDUCTION BY RAILROADS

The discussion which followed the testimony of Mr. Brandeis and others before the Interstate Commerce Commission in regard to cost reduction by railroads, recalled a letter received some months ago from an authority in the trade; and some extracts, given below, possess peculiar interest at this time, although the letter was written previous to the hearing referred to.

"We presume if all sellers were disposed to follow the methods that the big railroad tool houses follow in selling, that the business would be somewhat better distributed; but it seems to us this is not the right way to go about correcting a condition that undermines the mechanical departments of the railroads from one end to another.

"The railroads who lump their business ignore or deny the elementary fact that there is a big difference in the producing power of different makes of machines. People who are in the tool business, know that anyone can produce a commonplace machine, just as anyone can play a commonplace game of chess, for instance; but they also know it is only when natural-born builders of certain kinds of machine tools get into the game, that things really begin to happen. When it comes to demonstrating the final saving through employing efficient machines, we find the most satisfactory way is to get the cost of the machines down to so much per unit of time. For purposes of comparison, "interest and depreciation" can be taken as representing the yearly cost of machines. If you put this at 15 per cent a year, which allows 5 per cent for the use of the money and 10 per cent for depreciation, you take care of both interest and principal, as 10 per cent depreciation will bring a machine's holding price down to about one-half price in five years; and machinery men know second-hand machines can be actually sold or traded for one-half price in that time, in most cases. It is a fact that the producing capacity of different machines will vary much more than that; but in this argument, we will put it at 20 per cent. The average wages of railroad boring-mill hands, say, from one end of the country to the other will probably be close to $100 a month. Say the more efficient machine costs $200 more. Interest and depreciation on this amount would be $2.50 a month, and if it lets the man get out 20 per cent more work, it will save $20 a month or eight times its cost; or to put it in another way, if a machine saves $20 a month, you can actually afford to pay for it, over the price of a less efficient type, $1600 ($20 × 12 ÷ 15). Make liberal allowances for differences between practical conditions and theoretical, and you will still have a showing making absolute proof that efficiency and not price is the all-important thing. It is certainly not exaggerating to say that railroads will have a hard time finding a place where they can invest their resources to yield bigger returns than these; also that when any railroad official from the top to the bottom trifles with his responsibilities, when it comes to buying machine tools, the salary he is paid will seem ridiculously small compared with what his methods actually cost his road.

"It is impossible for any one concern to get together a line that will give it the best machines in *every* department. The efficiency of every manufacturer is constantly fluctuating, and changing agencies is a slow matter. It follows then that if business is lumped, some of the machines gotten must be poor ones. Obviously, the proper way is to pick out the machines individually, giving the big houses such items as they are entitled to, only. The big combinations claim they can sell for less, on account of owning or controlling factories, but there is really not much in this claim, as it is self-evident that any investment, by whomever owned must yield a regular profit. The margins on machine tools are very small to anybody, so that any quantity discount that could be made, while possibly seeming big at first glance, would really amount to little in view of the bigger earnings of efficient machines.

"Lumping orders at headquarters naturally causes inferences by the shop men that tend to create a cynical and careless attitude throughout the whole organization. Another very important point, as we see it, is the fact that such a policy makes enemies of a great many salesmen. The training of these men makes them know how to talk, and they are constantly circulating among a large number of business men, and consequently cannot help but exert an important influence in molding public sentiment against the railroads. It seems to us that the purchasing department of a railroad is a place for an accomplished diplomat. The roads might just as well have a lot of salesmen boosting their cause as knocking it.

"Many of the most successful lines, such as the Harriman System, Burlington, Pennsylvania, Chicago & North Western, and others, are waking up to the importance of careful selections of tools, and it is high time that this plan should become more general. Shop payrolls on some systems will probably exceed a quarter million dollars a *month*, so the issue is big enough."

* * *

PHYSICAL INJURY FROM DRAFTING

By B. L. W.

In a large drawing-room employing one hundred draftsmen there was a frequent call for contributions for flowers as a last tribute to a poor fellow-workman who had gone on his last trip. One old man in the place noted that a number of these men previous to their death had complained of pains in the abdominal region where the pressure comes in leaning over the drawing-board. Recently a workman who complained of a pain in his left side at this point was taken to a physician and a thorough examination was made, to find out if possible if there was any internal injury due to his work. The physician found two painful spots similarly located in the right and left sides. The one in the left side, which was the most painful, was in the neighborhood of the low rib and directly in line with the heart. Further examination showed that the floating rib was out of place, being lapped under the rib above it. This derangement, which had evidently been brought about by pressing against the drawing-board when at work, was causing an undue pressure on the spleen and on one of the large intestines, as well as some of the nerves, with the result of hampering the spleen in its action, thus causing an impoverishment of the blood and its resulting debility. There was also a weakened digestion from the pressure on the intestines and nerves, a state of debility and lack of nerve tone, which condition being continuous would probably result in some chronic ailment. There was at this time no direct injury to the heart.

Another draftsman was examined and found to have the same trouble—deranged ribs—but the displacement in this case was not so much as in the first one. Allowing for all this, draftsmen need not feel that they are martyrs over or above all others, as most lines of work have their resulting physical ills, and the purpose of this article is not to commiserate the poor draftsmen on their unfortunate position, but rather to decide where the trouble lies and to find out how to alleviate it.

First, it is well to remember how the Chinese doctor, who, when a patient with a broken rib was brought in, first stripped the man, and then threw a pail of cold water over his back. The resulting gasp of the poor victim was excruciatingly painful, but the ribs were snapped into place and the doctor could then strap up his patient and bring him around in fine shape.

For the same reason the draftsmen should frequently during the day, straighten up and breathe deeply. Further, it will be of particular benefit to take regular morning and evening waist exercises and also it would be a good idea to cut out beer and an osteopathist can correct any injury already done.

Another thought is to discard the old flat board, and work as the artists do, with the vertical board. This can be done with entire satisfaction by using a straightedge which has a parallel motion instead of a T-square. In each case the draftsman must follow his own way of doing things, and look to himself that he makes the work a stepping stone to something higher.

* * *

Copper and its alloys are affected by rubber, and hence copper and rubber should never be used in combination.

MILLING SCREW MACHINE CAMS*

By WILLIAM W. JOHNSON†

William W. Johnson‡

There are several methods used for finishing plate cams. Most methods require that the outline be accurately laid out, after which the stock is removed, generally by drilling a series of holes around the outline and breaking away the outer part. The cam is then finished to the scribed lines by milling and filing. This method, however, is slow, and the highest accuracy is not obtainable in this way.

Another method which is applicable to all cams with a constant rise is illustrated in the half-tone Fig. 1. A diagrammatical view of the relative positions of the compound vertical milling attachment and the index head used in this method, is shown in Fig. 2. By this method constant-rise cams may be milled, so to speak, automatically, by placing the cam blank on the index head spindle, and gearing the head for spiral milling. An end-mill is held in the compound vertical milling attachment, which is adjustable to any angle in the vertical plane, as indicated in Figs. 1 and 2. The milling attachment and the spiral head are set at a certain angle with the table surface, this angle being determined by the rise of the cam and the forward feed of the milling machine table for one turn of the index head spindle; this forward feed is usually called the spiral lead for which the machine is geared. It will be clear even to persons unfamiliar with this method, that when the table is feeding forward, the slowly revolving cam blank is fed against

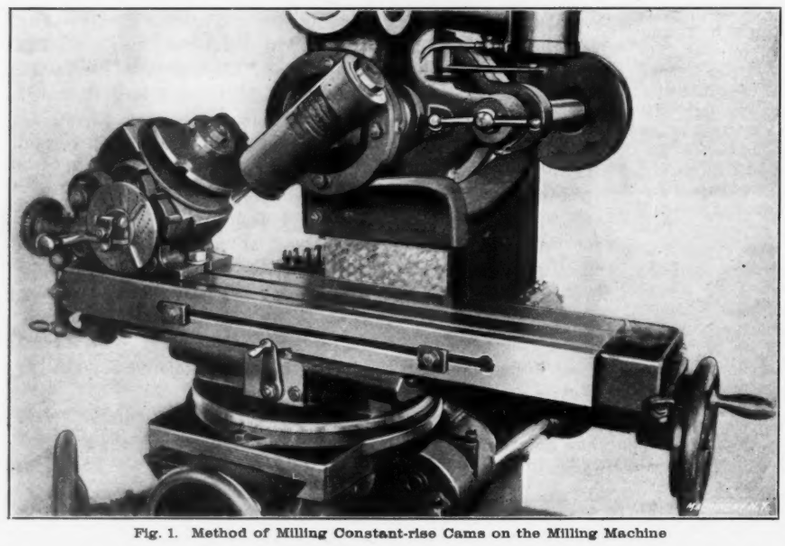

Fig. 1. Method of Milling Constant-rise Cams on the Milling Machine

the cutting edge of the end-mill, and as this latter is stationary, the radius of the cam will be constantly decreased. It is the object of this article to describe a method for finding the angle to which the spiral head is to be set, and the lead for which the spiral head is to be geared, so as to obtain very accurate results when milling constant-rise cams. The formulas given below and the tables in the accompanying Data Sheet Supplement, of leads obtainable on the Brown & Sharpe milling machines, and their logarithms, are used for facilitating the necessary calculations. In order to carry out the calculations by the method outlined, a table of logarithms of numbers (MACHINERY'S Reference Series No. 53) and a table of logarithms of angular functions (MACHINERY'S Reference Series No. 55) are required. In order to find the gears to be used for any spiral lead obtainable on the machine, a book

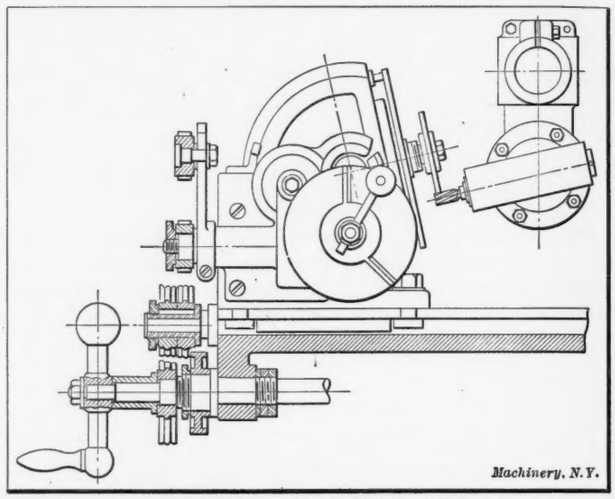

Fig. 2. Diagrammatical View showing Method of Milling Cams on the Milling Machine

entitled "Tables of Leads for Use with Universal Milling Machines," published by the Brown & Sharpe Mfg. Co., Providence, R. I., should be used.

General Formulas for the Calculations

In the following formulas let

l = lead of the cam lobe to be milled; the lead of the cam lobe is the rise of the cam if the given rate of rise were continued for one whole revolution or 360 degrees,

R = rise of the cam in a given part N of the circumference,

N = the part of the circumference in which a given rise takes place; N is expressed as a decimal in hundredths of the cam circumference,

L = spiral lead for which the milling machine is geared,

α = angle to which the index head and milling attachment are to be set.

The finding of the angle α to which the index head is to be set for any specific case is most easily explained by reference to Fig. 3. In the right-angle triangle shown, the hypotenuse L represents the distance that the milling machine table will be fed forward while the index head spindle makes one complete revolution, or, in other words, L is the spiral lead for which the machine is geared. The side l in the triangle represents the rise that the cam to be milled would have in 360 degrees, or in one complete revolution; hence, this side represents the lead of the cam. It is then clear that

$$\sin = \frac{l}{L} \qquad (1)$$

But $l = \frac{R}{N}$, hence:

$$\sin \alpha = \frac{R}{N \times L} \qquad (2)$$

It is apparent from Formula (2) that when R, N and L are known angle α can be determined. As it is not practicable, however, to set either the index head or the vertical

* With Data Sheet Supplement.

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‡ William W. Johnson was born in Cleveland, Ohio, in 1879. He received a business education, and training in the mechanical, electrical and advanced mathematical courses of the International Correspondence Schools. He served an apprenticeship with F. H. Bultman & Co., Cleveland, Ohio, general machinists and manufacturers of automatic gear cutters, and has worked for the Cleveland Automatic Machine Co., Warner & Swasey and Federal Mfg. Co., and the American Multigraph Sales Co., all of Cleveland, Ohio, with which concerns he has held positions as machinist, toolmaker, draftsman, jig and tool designer, chief draftsman, assistant superintendent and chief inspector. Mr. Johnson's specialty is drafting and jig and tool designing for interchangeable manufacture.

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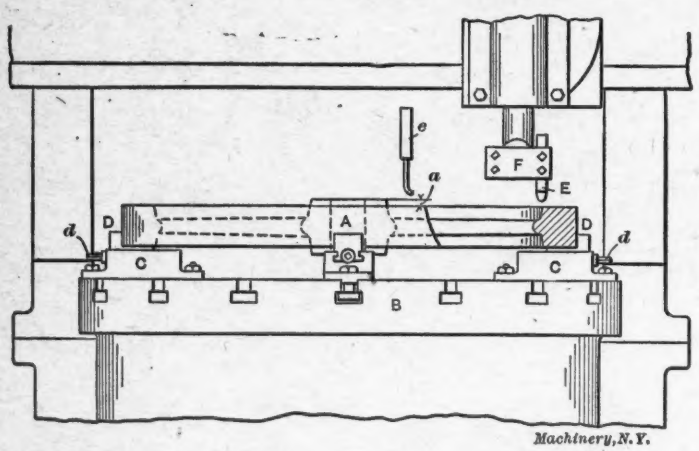
Supplement to MACHINERY, January, 1911

Operations for the Article in this number entitled "Machine Shop Practice—A Vertical Boring-mill Operation"

SHOP OPERATION SHEET NO. 157

Oscar E. Perrigo — MACHINERY, January, 1911



Machining a Balance Wheel Casting on a Vertical Boring Mill.—To Set the Work and Face Rim and Hub

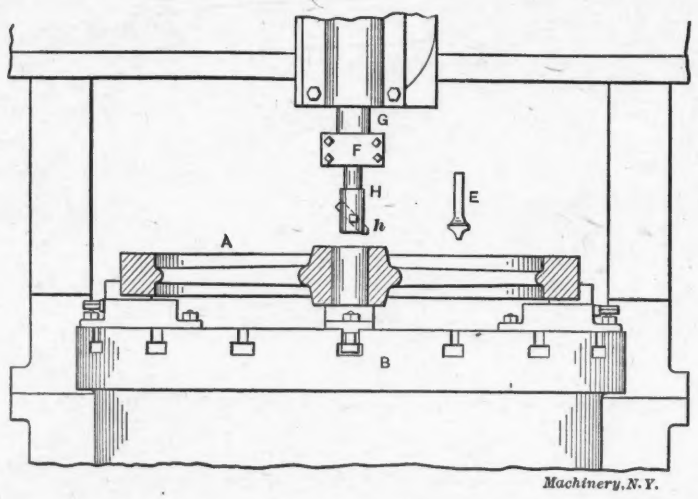
1. Place four independent chuck jaws *C* on the table *B*, at uniform distances from the edge, with their tongues in the T-slots, and secure them by the bolts at the ends.
2. With the screws *d* adjust the jaws *D* so as to admit the rim of the wheel casting *A*.
3. Place the casting *A* in the jaws *D*, and screw up the jaws lightly. Hold a piece of chalk against the inside of the rim, and rotate the table slowly. Move the casting by the jaw screws *d*, as indicated by the chalk marks, until it is set as nearly true as practicable. If the casting is slightly warped, place small steel wedges between it and the jaw faces, in order to equalize the distortion between top and bottom sides, which should be tested by a surface gage. Set up the jaws tightly.

NOTE.—When, as in this case, the inside of the rim is not to be machined, it is good practice to set the casting by the inside so that the wheel, when finished, will have a rim of uniform thickness. A handy tool for setting work of this kind consists of a wooden shank *e* into the end of which is inserted a bent wire as shown. The shank is clamped in the tool-head, and the wire, which is flexible, is brought against the work which is set by it.

4. Place a roughing tool *E*, in the tool clamp *F*. Set the tool and take a cut on the rim, deep enough to fully clean the casting and take off about half the surplus stock.
5. Start up the machine with a speed of about sixty feet per minute, and a feed of about ⅛ inch per revolution, and take a roughing cut. The feed will have to be regulated according to the power of the machine, the depth of the cut, and the nature of the material being turned.
6. Raise the tool a distance equal to the dimension *a*, and take a roughing cut over the hub.
7. Replace the roughing tool with a finishing tool having a cutting edge ½ to ¾ inch wide, and take the finishing cut, using a coarse feed of at least ¼ or ⅜ inch per revolution.

SHOP OPERATION SHEET NO. 158

Oscar E. Perrigo — MACHINERY, January, 1911



Machining a Balance Wheel Casting on a Vertical Boring Mill.—To Bore and Ream the Hole

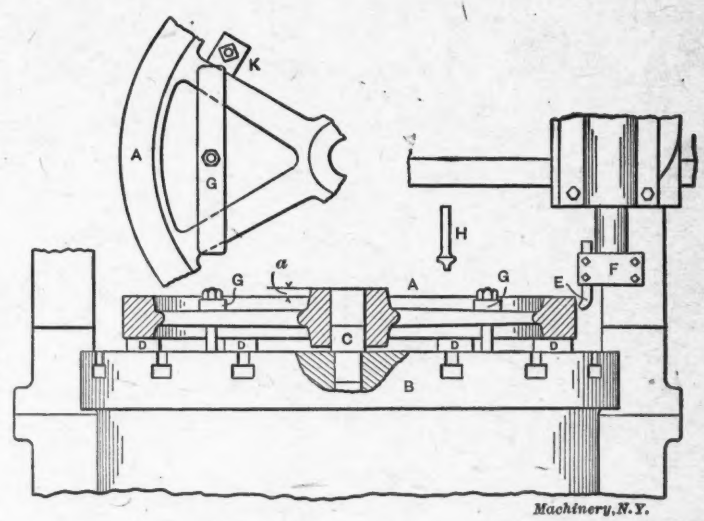
NOTE.—The casting is supposed to be set in the chuck jaws as described in the previous Operation Sheet.

1. Bring the tool-head *G* over the center of the table *B* and insert in it the boring-bar *H*, carrying the rough-boring tool *h*.
2. Adjust the tool so that it will take a cut which will true up the inside of the cored hole, and take a roughing cut. Run the machine at about forty feet per minute, and with a moderate down feed.
3. Replace the rough boring tool with a sharp one for sizing, and with the same speed, but somewhat less feed, take a sizing cut to within 1/64 inch of the finish diameter.
4. Replace the boring-bar *H* with a shell reamer, preferably loosely attached, and with a slow speed, force it down by the hand feed until the lower end is an inch or so through the lower side of the hub.
5. Remove the reamer and place, vertically, in the tool-clamp *F*, the formed tool *E* which is used for rounding the sharp corners of the rim and hub.
6. Bring this tool to a cutting position at the corner of the hub and, using the hand feed, carefully round the corner. Move the tool over to the inside of the rim and repeat the operation.

NOTE.—Some boring mills are provided with bars which not only fit into the tool-head *F*, but which have extensions passing through a bushed hole in the center of the table. This extension, of course, greatly steadies the bar. Double-ended cutters which pass through a slot in the bar are at times used instead of the type shown. These may be made in both roughing and finishing sizes. The reamer is, however, preferable when a number of wheels need to be bored to a standard size.

SHOP OPERATION SHEET NO. 159

Oscar E. Perrigo — MACHINERY, January, 1911



Machining a Balance Wheel Casting on a Vertical Boring Mill.—To Face the Rim and Hub and Turn the Outside

1. In the center hole of the table *B*, fit a plug *C*, whose upper end fits snugly the reamed hole in the casting *A*.
2. Place casting *A* on table *B* with hub raised clear of table by six parallel blocks *D*, plug *C* entering the bored hole in the hub.
3. Secure the casting to the table by two or three stiff bars *G*, tightened upon the arms of the wheel by bolts in the T-slots. Bolt a block *K* to the table and set it against one of the arms, to take the thrust of heavy outside cuts. If very heavy cuts are to be taken, it is well to have a second block *K* set against the arm on the opposite side of the wheel.
4. In tool-clamp *F* place a bent roughing tool *E*, and set it to fully clean the outside of the rim. Take the cut at a speed of about sixty feet per minute, and with as coarse a feed as possible.
5. If necessary, take a sizing cut to within 1/16 inch of the finish diameter.
6. Replace the roughing tool with a bent finishing tool having a straight cutting edge or face, and finish the casting to the required diameter, using a comparatively coarse feed.
7. Replace the finishing tool by a straight roughing tool, and take a roughing cut over the rim face, to within 1/32 inch of the finish width. Raise the tool an amount equal to dimension *a*, and take a roughing cut over the face of the hub.
8. Replace the roughing tool with a finishing tool, finish the rim to required dimension, and then the hub, raising the tool a distance *a*.
9. Replace the finishing tool by a formed tool *H*, set vertically, and with a hand feed, round the corner of the hub and the inner corner of the rim.

DATA FOR MILLING B. & S. SCREW MACHINE CAMS—II

Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm

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DATA FOR MILLING B. & S. SCREW MACHINE CAMS—I

USE OF TABLES IN MILLING CAMS

The formula below and the accompanying tables of leads obtainable on the Brown & Sharpe milling machines, and their logarithms, are used for determining the angular setting of the spiral head when milling constant-rise cams by the method here illustrated.

Let R be the rise of the cam in a given part, N, of the cam circumference. N is expressed as a decimal in hundredths of the circumference. Let L be the lead to be found for which the spiral head is to be geared, and a the angle to which to set the head and milling attachment.

$$\text{Then, } \sin a = \frac{R}{N \times L}$$

Hence, when R, N and L are known, angle a can be determined. As it is not practicable, however, to set either the head or the milling attachment closer than to whole or half degrees, the lead L must be so selected that angle a is within 5 minutes either way of a whole or half degree. Hence trial calculations must be made, and it is to facilitate these that the tables have been prepared.

Example: Rise of cam 0.155 inch in 0.24 of circumference. Find L and a.

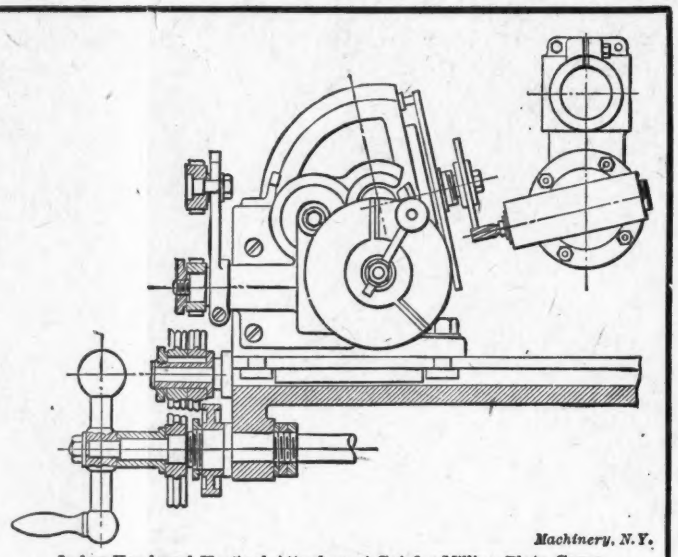
$$\text{Sin } a = \frac{0.155}{0.24 \times L} = \frac{0.6458}{L}$$

Find the logarithm for 0.6458. (See MACHINERY'S Reference Series No. 53 for tables of logarithms.)

$$\text{Log } 0.6458 = \bar{1}.81010.$$

Now, beginning with a lead L *larger* than the numerator 0.6458, subtract the logarithms of the leads, as found in the accompanying tables, from the logarithm of the numerator 0.6458, until by repeated trials, a remainder is obtained which is the logarithm of the sine of an angle which is within 5 minutes of a whole or half degree. The angle thus found is the setting angle for the lead, and the lead giving this angle is the one for which the spiral head is to be geared.

Proceeding according to the directions above, we have



Machinery, N.Y.

Index Head and Vertical Attachment Set for Milling Plate Cams

$$\begin{aligned} &\log 0.6458 = \bar{1}.81010 \\ \text{(subtract)}\ &\log 0.900 = \bar{1}.95424 \\ &\log \sin a = \bar{1}.85586 \end{aligned}$$

From a table of logarithms of sines (see MACHINERY'S Reference Series No. 55), we find $a = 45° 51'$. As this angle is not within 5 minutes of a whole or half degree, try the next lead in Table II:

$$\begin{aligned} &\log 0.6458 = \bar{1}.81010 \\ \text{(subtract)}\ &\log 0.930 = \bar{1}.96848 \\ &\log \sin a = \bar{1}.84162, \text{ and } a = 43° 59'. \end{aligned}$$

This angle fills the requirements. Hence, set head and attachment to 44 degrees, and find the gears to use for 0.930 lead from Brown & Sharpe Mfg. Co.'s book "Table of Leads for Use with Universal Milling Machine."

Contributed by William W. Johnson

No. 188, Data Sheet, MACHINERY, January, 1911

DATA FOR MILLING B. & S. SCREW MACHINE CAMS—II

Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm
0.900	$\bar{1}$.95424	1.776	0.24944	2.333	0.36791	2.894	0.46150	3.429	0.53517
0.930	$\bar{1}$.96848	1.778	0.24993	2.338	0.36884	2.909	0.46374	3.438	0.53631
0.933	$\bar{1}$.96988	1.786	0.25188	2.344	0.36996	2.917	0.46494	3.488	0.54258
1.029	0.01242	1.800	0.25527	2.368	0.37438	2.924	0.46598	3.491	0.54295
1.042	0.01787	1.809	0.25744	2.381	0.37676	2.933	0.46731	3.492	0.54307
1.047	0.01995	1.818	0.25959	2.386	0.37767	2.934	0.46746	3.500	0.54407
1.050	0.02119	1.823	0.26079	2.392	0.37876	2.946	0.46923	3.520	0.54654
1.067	0.02816	1.860	0.26851	2.400	0.38021	2.950	0.46982	3.535	0.54839
1.085	0.03543	1.861	0.26975	2.424	0.38453	2.977	0.47378	3.552	0.55047
1.116	0.04766	1.867	0.27114	2.431	0.38578	2.984	0.47480	3.556	0.55096
1.196	0.07773	1.875	0.27300	2.442	0.38775	3.000	0.47712	3.564	0.55194
1.200	0.07918	1.886	0.27554	2.445	0.38828	3.030	0.48144	3.565	0.55206
1.221	0.08672	1.905	0.27989	2.450	0.38917	3.044	0.48344	3.571	0.55279
1.228	0.08920	1.919	0.28307	2.456	0.39023	3.055	0.48501	3.572	0.55291
1.240	0.09342	1.920	0.28330	2.481	0.39463	3.056	0.48515	3.582	0.55413
1.244	0.09482	1.925	0.28443	2.489	0.39602	3.070	0.48714	3.588	0.55485
1.250	0.09691	1.944	0.28870	2.500	0.39794	3.080	0.48855	3.600	0.55680
1.302	0.11461	1.954	0.29092	2.514	0.40037	3.086	0.48940	3.618	0.55847
1.309	0.11694	1.956	0.29137	2.532	0.40346	3.101	0.49150	3.636	0.56062
1.333	0.12488	1.990	0.29885	2.537	0.40432	3.111	0.49290	3.637	0.56074
1.340	0.12710	1.993	0.29950	2.546	0.40586	3.117	0.49374	3.646	0.56182
1.371	0.13704	2.000	0.30103	2.558	0.40790	3.125	0.49485	3.655	0.56289
1.395	0.14457	2.009	0.30298	2.567	0.40943	3.126	0.49499	3.657	0.56312
1.400	0.14613	2.030	0.30750	2.571	0.41010	3.140	0.49693	3.663	0.56384
1.429	0.15503	2.035	0.30856	2.593	0.41380	3.143	0.49734	3.667	0.56431
1.433	0.15625	2.036	0.30878	2.605	0.41581	3.150	0.49831	3.673	0.56502
1.440	0.15836	2.045	0.31069	2.618	0.41797	3.175	0.50174	3.684	0.56632
1.447	0.16047	2.047	0.31112	2.619	0.41814	3.182	0.50270	3.686	0.56656
1.458	0.16376	2.057	0.31323	2.625	0.41913	3.189	0.50365	3.704	0.56867
1.467	0.16643	2.067	0.31534	2.640	0.42160	3.190	0.50379	3.721	0.57066
1.488	0.17260	2.083	0.31869	2.658	0.42455	3.198	0.50488	3.733	0.57206
1.500	0.17609	2.084	0.31880	2.667	0.42602	3.200	0.50515	3.750	0.57403
1.523	0.18241	2.093	0.32077	2.674	0.42716	3.214	0.50705	3.763	0.57553
1.527	0.18384	2.100	0.32222	2.678	0.42781	3.225	0.50853	3.771	0.57646
1.550	0.19033	2.121	0.32654	2.679	0.42797	3.241	0.51068	3.772	0.57657
1.556	0.19201	2.133	0.32899	2.700	0.43136	3.256	0.51268	3.799	0.57967
1.563	0.19396	2.143	0.33102	2.713	0.43345	3.267	0.51415	3.809	0.58081
1.595	0.20276	2.171	0.33666	2.727	0.43569	3.273	0.51495	3.810	0.58092
1.600	0.20413	2.178	0.33806	2.743	0.43823	3.275	0.51521	3.818	0.58184
1.607	0.20602	2.182	0.33885	2.750	0.43933	3.281	0.51601	3.819	0.58195
1.638	0.21165	2.188	0.34005	2.778	0.44373	3.300	0.51851	3.822	0.58229
1.637	0.21405	2.193	0.34104	2.791	0.44576	3.308	0.51957	3.837	0.58399
1.650	0.21748	2.200	0.34242	2.800	0.44716	3.333	0.52284	3.840	0.58433
1.667	0.22194	2.222	0.34674	2.812	0.44902	3.345	0.52440	3.850	0.58546
1.674	0.22376	2.233	0.34889	2.828	0.45148	3.349	0.52492	3.876	0.58838
1.680	0.22531	2.238	0.34986	2.843	0.45378	3.360	0.52634	3.889	0.58984
1.706	0.23198	2.240	0.35025	2.845	0.45408	3.383	0.52930	3.896	0.59062
1.711	0.23325	2.250	0.35218	2.849	0.45469	3.403	0.53186	3.907	0.59184
1.714	0.23401	2.274	0.35679	2.857	0.45591	3.409	0.53263	3.911	0.59229
1.744	0.24155	2.286	0.35908	2.865	0.45712	3.411	0.53288	3.920	0.59329
1.745	0.24180	2.292	0.36021	2.867	0.45743	3.422	0.53428	3.927	0.59406
1.750	0.24304	2.326	0.36661	2.880	0.45939	3.428	0.53504	3.929	0.59428

Contributed by William W. Johnson

No. 188, Data Sheet, MACHINERY, January, 1911

DATA FOR MILLING B. & S. SCREW MACHINE CAMS—III

Contributed by William W. Johnson

Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm
3.977	0.59956	4.572	0.66011	5.160	0.71265	5.848	0.76701	6.548	0.81611
3.979	0.59977	4.582	0.66106	5.168	0.71332	5.861	0.76797	6.563	0.81710
3.987	0.60065	4.583	0.66115	5.185	0.71475	5.867	0.76842	6.578	0.81809
4.000	0.60206	4.584	0.66124	5.186	0.71483	5.893	0.77034	6.600	0.81954
4.011	0.60325	4.651	0.66755	5.195	0.71559	5.912	0.77173	6.645	0.82249
4.019	0.60412	4.655	0.66792	5.209	0.71675	5.920	0.77232	6.667	0.82393
4.040	0.60638	4.667	0.66904	5.210	0.71684	5.926	0.77276	6.689	0.82536
4.059	0.60842	4.675	0.66978	5.226	0.71817	5.952	0.77466	6.697	0.82588
4.060	0.60853	4.687	0.67089	5.233	0.71875	5.954	0.77481	6.698	0.82595
4.070	0.60959	4.688	0.67099	5.236	0.71900	5.969	0.77590	6.719	0.82730
4.073	0.60991	4.691	0.67127	5.238	0.71917	5.972	0.77612	6.720	0.82737
4.074	0.61002	4.714	0.67339	5.250	0.72016	5.980	0.77670	6.735	0.82834
4.091	0.61183	4.736	0.67541	5.256	0.72066	6.000	0.77815	6.750	0.82930
4.093	0.61204	4.762	0.67779	5.280	0.72263	6.016	0.77931	6.757	0.82975
4.114	0.61426	4.773	0.67879	5.303	0.72452	6.020	0.77960	6.766	0.83033
4.125	0.61542	4.778	0.67925	5.316	0.72558	6.061	0.78254	6.784	0.83149
4.135	0.61648	4.784	0.67979	5.328	0.72656	6.077	0.78369	6.806	0.83289
4.144	0.61742	4.785	0.67988	5.333	0.72697	6.089	0.78455	6.818	0.83366
4.167	0.61982	4.800	0.68124	5.347	0.72811	6.109	0.78597	6.822	0.83391
4.186	0.62180	4.813	0.68242	5.348	0.72819	6.112	0.78618	6.825	0.83410
4.200	0.62325	4.821	0.68314	5.357	0.72892	6.122	0.78689	6.857	0.83613
4.242	0.62757	4.849	0.68565	5.358	0.72900	6.125	0.78711	6.875	0.83727
4.253	0.62870	4.861	0.68673	5.375	0.73038	6.137	0.78796	6.880	0.83759
4.264	0.62982	4.884	0.68878	5.400	0.73239	6.140	0.78817	6.944	0.84161
4.267	0.63012	4.889	0.68922	5.413	0.73344	6.143	0.78838	6.945	0.84167
4.278	0.63124	4.898	0.69002	5.426	0.73448	6.160	0.78958	6.968	0.84311
4.286	0.63205	4.900	0.69020	5.427	0.73456	6.171	0.79036	6.977	0.84367
4.300	0.63347	4.911	0.69117	5.444	0.73592	6.172	0.79043	6.982	0.84398
4.320	0.63548	4.914	0.69144	5.455	0.73679	6.202	0.79253	6.984	0.84410
4.341	0.63759	4.950	0.69461	5.469	0.73791	6.222	0.79393	7.000	0.84510
4.342	0.63769	4.961	0.69557	5.473	0.73823	6.234	0.79477	7.013	0.84590
4.361	0.63959	4.978	0.69705	5.486	0.73926	6.250	0.79588	7.040	0.84757
4.363	0.63979	4.984	0.69758	5.500	0.74036	6.255	0.79623	7.071	0.84948
4.364	0.63988	5.000	0.69897	5.556	0.74476	6.279	0.79789	7.104	0.85150
4.365	0.63998	5.017	0.70044	5.568	0.74570	6.286	0.79837	7.106	0.85163
4.375	0.64098	5.023	0.70096	5.581	0.74671	6.300	0.79934	7.111	0.85193
4.386	0.64207	5.029	0.70148	5.582	0.74679	6.343	0.80229	7.130	0.85309
4.400	0.64345	5.040	0.70243	5.600	0.74819	6.350	0.80277	7.143	0.85388
4.444	0.64777	5.074	0.70535	5.625	0.75012	6.364	0.80373	7.159	0.85485
4.465	0.64982	5.080	0.70586	5.657	0.75259	6.379	0.80475	7.163	0.85509
4.466	0.64992	5.088	0.70655	5.698	0.75572	6.396	0.80591	7.167	0.85534
4.477	0.65099	5.091	0.70680	5.714	0.75694	6.400	0.80618	7.176	0.85588
4.479	0.65118	5.093	0.70697	5.730	0.75815	6.417	0.80733	7.200	0.85733
4.480	0.65128	5.105	0.70800	5.733	0.75838	6.429	0.80814	7.268	0.86141
4.500	0.65321	5.116	0.70893	5.756	0.76012	6.450	0.80956	7.272	0.86165
4.522	0.65533	5.119	0.70919	5.759	0.76035	6.460	0.81023	7.273	0.86171
4.537	0.65677	5.120	0.70927	5.760	0.76042	6.465	0.81057	7.292	0.86285
4.545	0.65753	5.133	0.71037	5.788	0.76253	6.482	0.81171	7.310	0.86392
4.546	0.65763	5.134	0.71046	5.814	0.76448	6.512	0.81371	7.314	0.86415
4.548	0.65782	5.142	0.71118	5.818	0.76477	6.515	0.81391	7.326	0.86487
4.558	0.65877	5.143	0.71122	5.833	0.76589	6.534	0.81518	7.330	0.86510
4.567	0.65963	5.156	0.71231	5.847	0.76693	6.545	0.81591	7.333	0.86528

DATA FOR MILLING B. & S. SCREW MACHINE CAMS—IV

Contributed by William W. Johnson

Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm	Spiral Lead	Logarithm
7.334	0.86534	8.081	0.90747	8.953	0.95197	9.828	0.99247	10.800	1.03342
7.347	0.86611	8.102	0.90859	8.959	0.95226	9.844	0.99317	10.853	1.03555
7.371	0.86753	8.119	0.90950	8.960	0.95231	9.900	0.99564	10.859	1.03579
7.372	0.86759	8.140	0.91062	8.980	0.95328	9.921	0.99656	10.909	1.03778
7.400	0.86923	8.145	0.91089	9.000	0.95424	9.923	0.99664	10.913	1.03794
7.408	0.86970	8.148	0.91105	9.044	0.95636	9.943	0.99752	10.937	1.03890
7.424	0.87064	8.149	0.91110	9.074	0.95780	9.954	0.99800	10.945	1.03922
7.442	0.87169	8.163	0.91185	9.091	0.95861	9.967	0.99856	10.949	1.03937
7.465	0.87303	8.167	0.91206	9.115	0.95976	9.968	0.99861	10.972	1.04029
7.467	0.87315	8.182	0.91286	9.134	0.96066	10.000	1.00000	11.000	1.04139
7.500	0.87506	8.186	0.91307	9.137	0.96080	10.033	1.00143	11.021	1.04222
7.525	0.87651	8.212	0.91445	9.143	0.96109	10.046	1.00199	11.057	1.04364
7.543	0.87754	8.229	0.91535	9.164	0.96209	10.057	1.00247	11.111	1.04575
7.576	0.87944	8.250	0.91645	9.167	0.96223	10.078	1.00337	11.137	1.04677
7.597	0.88064	8.306	0.91939	9.210	0.96426	10.080	1.00346	11.160	1.04766
7.601	0.88087	8.312	0.91971	9.214	0.96445	10.101	1.00436	11.163	1.04778
7.611	0.88144	8.333	0.92080	9.260	0.96661	10.159	1.00685	11.169	1.04801
7.619	0.88190	8.334	0.92085	9.302	0.96858	10.175	1.00753	11.198	1.04914
7.620	0.88195	8.361	0.92226	9.303	0.96862	10.182	1.00783	11.200	1.04922
7.636	0.88287	8.372	0.92283	9.333	0.97002	10.186	1.00800	11.225	1.05019
7.639	0.88304	8.377	0.92309	9.334	0.97007	10.209	1.00898	11.250	1.05115
7.644	0.88332	8.400	0.92428	9.351	0.97086	10.228	1.00979	11.313	1.05358
7.657	0.88406	8.437	0.92619	9.375	0.97197	10.233	1.01000	11.314	1.05362
7.674	0.88502	8.457	0.92722	9.382	0.97230	10.238	1.01022	11.363	1.05549
7.675	0.88508	8.484	0.92860	9.385	0.97243	10.267	1.01144	11.401	1.05694
7.679	0.88530	8.485	0.92865	9.406	0.97340	10.286	1.01225	11.429	1.05801
7.680	0.88536	8.506	0.92973	9.428	0.97442	10.312	1.01334	11.454	1.05896
7.700	0.88649	8.523	0.93059	9.429	0.97447	10.313	1.01338	11.459	1.05915
7.714	0.88728	8.527	0.93080	9.460	0.97589	10.320	1.01368	11.467	1.05945
7.752	0.88941	8.532	0.93105	9.472	0.97644	10.336	1.01435	11.512	1.06115
7.778	0.89087	8.534	0.93115	9.524	0.97882	10.370	1.01578	11.518	1.06138
7.792	0.89165	8.552	0.93207	9.545	0.97978	10.371	1.01582	11.520	1.06145
7.813	0.89282	8.556	0.93227	9.546	0.97982	10.390	1.01662	11.574	1.06348
7.815	0.89293	8.572	0.93308	9.547	0.97987	10.417	1.01774	11.629	1.06554
7.818	0.89310	8.594	0.93420	9.549	0.97996	10.419	1.01783	11.638	1.06588
7.838	0.89421	8.600	0.93450	9.556	0.98028	10.451	1.01916	11.667	1.06696
7.855	0.89515	8.640	0.93651	9.569	0.98087	10.467	1.01982	11.688	1.06774
7.857	0.89526	8.681	0.93857	9.598	0.98218	10.473	1.02007	11.695	1.06800
7.872	0.89609	8.682	0.93862	9.600	0.98227	10.476	1.02020	11.719	1.06889
7.875	0.89625	8.687	0.93887	9.625	0.98340	10.477	1.02024	11.721	1.06896
7.883	0.89669	8.721	0.94057	9.643	0.98421	10.500	1.02119	11.728	1.06922
7.920	0.89873	8.727	0.94086	9.675	0.98565	10.558	1.02358	11.733	1.06941
7.936	0.89960	8.730	0.94101	9.690	0.98632	10.571	1.02412	11.757	1.07030
7.954	0.90059	8.750	0.94201	9.697	0.98664	10.606	1.02555	11.785	1.07133
7.955	0.90064	8.772	0.94310	9.723	0.98780	10.631	1.02657	11.786	1.07137
7.963	0.90108	8.800	0.94448	9.741	0.98860	10.655	1.02755	11.825	1.07280
7.974	0.90168	8.888	0.94635	9.768	0.98981	10.659	1.02772	11.852	1.07379
7.994	0.90276	8.839	0.94640	9.773	0.99003	10.667	1.02804	11.905	1.07573
8.000	0.90309	8.889	0.94885	9.778	0.99025	10.694	1.02914	11.938	1.07698
8.021	0.90423	8.909	0.94983	9.796	0.99105	10.713	1.02991	11.944	1.07715
8.035	0.90499	8.929	0.95080	9.818	0.99202	10.714	1.02995	11.960	1.07773
8.063	0.90650	8.930	0.95085	9.822	0.99220	10.750	1.03141	12.000	1.07918

milling attachment closer than to whole or half degrees, the lead L must be so selected that the angle α will be within 5 minutes either way of a whole or a half degree. Hence trial calculations must be made, and it is for the purpose of facilitating these calculations that the tables in the accompanying Data Sheet Supplement have been prepared.

Practical Use of Tables and Formulas

The practical use of the formulas given and of the tables in the Data Sheet Supplement can be best explained by means

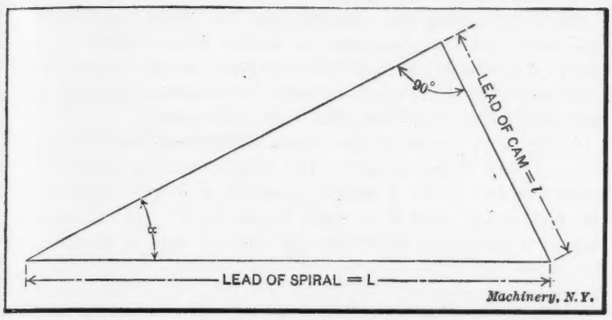


Fig. 3. Relation between Setting Angle of Index Head, Spiral Lead and Lead of Cam Lobe

of an example. Assume that a set of cams is designed and drawn as shown in Fig. 4, and that the toolmaker is to be given the necessary data for milling the lobes on these cams. The milling is to be done according to the methods illustrated in Figs. 1 and 2. The calculations should be made by the draftsman or whoever designs the cams, and it is recommended that the results of the calculations be tabulated as shown in the table. Referring to the cam drawings in Fig. 4, let us first take the first lobe on the front-slide cam. Here the rise $R = 0.155$ inch and this rise takes place in 0.24 of the whole cam circumference. Hence $N = 0.24$. We have further:

$$l = \frac{R}{N} = \frac{0.155}{0.24} = 0.6458$$

and, from Formula (1):

$$\sin \alpha = \frac{l}{L} = \frac{0.6458}{L}$$

As already mentioned we must now find a lead L so selected that angle α will be within 5 minutes either way of a whole or half degree. In order to accomplish this result proceed as follows:

First find the logarithm of 0.6458:

$$\log 0.6458 = \bar{1}.81010$$

Now turn to the tables of leads in the accompanying Data Sheet Supplement. Beginning with any lead L that is *larger* than the numerator 0.6458, subtract the logarithms of the leads, as found in the tables, from the logarithm in the numerator 0.6458 until, by repeated trials, a remainder is obtained which is the logarithm of the sine of an angle which is within 5 minutes of a whole or a half degree. The angle thus found is the setting angle for the index head, and the lead giving this angle is the one for which the head is to be geared. Proceeding according to the directions given above we have:

$$\begin{array}{rl} & \log 0.6458 = \bar{1}.81010 \\ \text{(Subtract)} & \log 0.900 = \bar{1}.95424 \\ \hline & \log \sin \alpha = \bar{1}.85586 \end{array}$$

From a table of logarithms of sines we find that $\alpha = 45$ degrees 51 minutes. As this angle is not within 5 minutes of a whole or a half degree, try the next lead in Table II in the Supplement, as follows:

$$\begin{array}{rl} & \log 0.6458 = \bar{1}.81010 \\ \text{(Subtract)} & \log 0.930 = \bar{1}.96848 \\ \hline & \log \sin \alpha = \bar{1}.84162 \end{array}$$

Hence $\alpha = 43$ degrees 59 minutes.

This angle fills the requirements. No more trials are, therefore, required, and the index head and the compound vertical milling attachment are to be set to 44 degrees; the gears to use for gearing the spiral head for 0.930 inch lead are found from Brown & Sharpe Mfg. Co.'s book "Table of Leads for Use with Universal Milling Machines," as already mentioned.

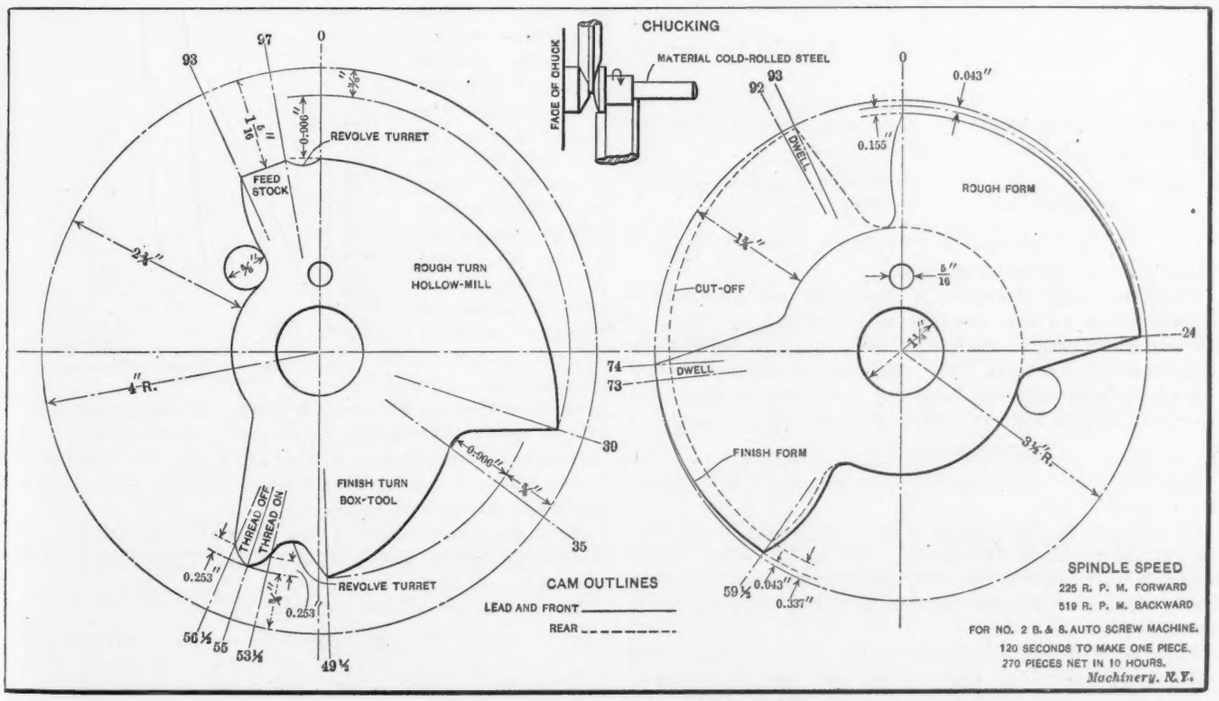


Fig. 4. Cams used as Examples in the Calculations

In using this method, the following conditions must be taken into consideration:

If a spiral lead can be found in the tables in the Supplement which is exactly equal to the numerator l in the fraction giving sin α in Formula (1), then this lead is the lead for which the spiral head is to be geared. It will be seen that sin α in this case becomes equal to 1, which is the sine of 90 degrees. This indicates that the compound vertical milling attachment and the index head are to be set in a vertical position. The calculations required for this case then become very simple, as no further trials are necessary.

Especial attention should be given to the fact that the spiral leads L used in the trial calculations must be larger than the numerator l in the fraction giving sin a in Equation (1). If the number expressing the lead were not greater than the numerator, the value of the fraction would be greater than 1, but as the sines of all angles are smaller than 1, this would be an impossible condition.

In finding the lead corresponding to a suitable angle, a simple way is to write the logarithm of the lead L on the upper edge of a second sheet of paper and to hold this under the originally written value of the logarithm of the numerator l in Formula (1), putting the difference on the second sheet of paper until a logarithm of sin a is found, giving a suitable

TABLE OF RESULTS OBTAINED BY THE CALCULATIONS FOR ANGLE AND LEAD

Piece No. 4-817
Computed by H. W. E.
Checked by W. W. J.
Date: Nov. 17, 1910

For Cam Chart D-904
(See Fig. 4)

Name of Cam	Rise on Cam in Inches	Number of Hundredths	Angle a in Degrees	Lead in Inches	Gear on Worm	First Gear on Stud	Second Gear on Stud	Gear on Screw
Lead cam	0.906	30	76	3.111	40	72	56	100
Lead cam	0.906	14½	80	6.343	100	44	24	86
Front cam	0.155	24	44	0.930	24	72	24	86
Front cam	0.043	13½	20	0.930	24	72	24	86
Rear cam	0.337	32½	82	1.047	24	64	24	86

angle, as explained above. This saves repeating the writing down of the logarithm of the numerator l for each trial subtraction.

As another example illustrating what has been said, we may calculate the first lobe on the lead cam. Here $L = 0.906$, $N = 0.30$. Hence $l = \frac{0.906}{0.30} = 3.02$. It is found by repeated trials, starting with $L = 3.03$, that no lead gives an angle a even approximately within the given requirements, before we come to the lead 3.111:

$$\begin{aligned} &\log 3.02 &&= 0.48001 \\ \text{(Subtract)}\quad &\log 3.111 &&= 0.49290 \\ &\log \sin a &&= \bar{1}.98711 \end{aligned}$$

Hence $a = 76$ degrees 6 minutes.

While the angle 76 degrees 6 minutes is not quite within the limits that we have specified, it is so nearly so that it is safe enough to assume the setting angle to be 76 degrees, the corresponding lead being 3.111. We can calculate the actual rise of the cam with this lead and angle and compute the error resulting in the rise. From Formula (2) we have:

$$R = \sin a \times N \times L \qquad (4)$$

Inserting $a = 76$ degrees, $N = 0.30$, and $L = 3.111$, we obtain $R = 0.9056$ inch.

The error in the rise thus is 0.0004 inch, which for all practical purposes can be disregarded. The same method is employed for the other lobes. With a little practice, the work can be carried on rapidly, and the method is very simple to remember.

While it is the best practice always to use a spiral lead which corresponds to an angle within 5 minutes of a whole or half degree, as stated, yet a considerable amount of time may be saved in milling cam lobes with several leads, when the greatest accuracy may not be required, by gearing the machine for the greatest lead of lobe and changing the setting angle of the head for the other leads.

* * *

Joseph Brucker, a German-American journalist, will attempt to eclipse Wellman next year. Brucker will make an attempt to cross the Atlantic from the Canary Islands to the West Indies with an airship 200 feet long, now nearing completion. This airship has a gas capacity of nearly 300,000 cubic feet, and is driven by two 200-horsepower motors. A motor-boat 35 feet long and 10 feet wide will serve as a car.

CAST-IRON BRACKET USED AS AN OBLIQUE CANTILEVER

By J. H. C.

A bracket similar to that shown in Fig. 1 had to be designed to carry a very heavy load. The conditions being quite different from those of an ordinary cantilever, whose neutral axis is at right angles to the vertical load line, led to an investigation of the stresses involved. For small brackets with light loads, one would probably hit safe proportions without calculating the strength, but for heavy loads with a long lever arm, for the sake of safety, a few figures do no harm. The result of the investigation spoken of above is here given, with the hope of being interesting to some who may have occasion to use this style of bracket.

In Fig. 1, by means of the triangle of forces, the downward force or load P may be resolved at point O into its components, which are two forces N and R, where N is in the direction of the neutral axis and R at right angles to it. Fig. 2 shows a part of a cantilever in which the forces N and R are taking the place of their resultant, the downward force or load P. The internal force n is resisting the compression due to the outward force N, and is distributed equally over the entire sectional area. The internal resisting forces B, which are compression stresses, and T, which are tensile stresses, are the greatest stresses in the beam due to R. The terms R, T and B are identical with those in the theory of beam flexure. We then have a cantilever of length L inches, loaded with R pounds at the end. In Fig. 1, if the section is symmetrical, the greatest unit stress will occur at point e, for unit compressions due to N and R are added at this point, while at point f, the unit tensile stress due to R is offset by the unit compressive stress due to N, the resisting stresses T and B (Fig. 2) being equal for this style of section.

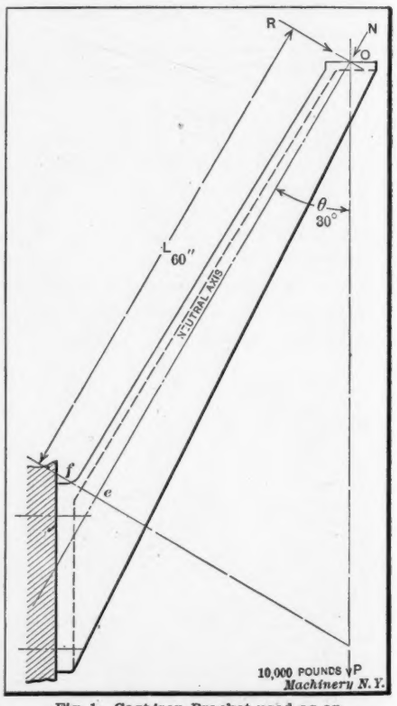


Fig. 1. Cast-iron Bracket used as an Oblique Cantilever

Let the greatest combined unit stress at e equal S; B = unit compressive stress due to R, and a = unit compressive stress due to N. Then $S = B + a$.

From the regular beam formula

$$B = \frac{RL}{Z}$$

where Z = section modulus.

We also have:

$$a = \frac{N}{A}, \text{ where } A = \text{area of section.}$$

$$\text{Then } S = \frac{RL}{Z} + \frac{N}{A}$$

But $R = P \sin \theta$, and $N = P \cos \theta$.

Therefore, by substituting:

$$S = \frac{P \sin \theta \times L}{Z} + \frac{P \cos \theta}{A} = P\left(\frac{L \sin \theta}{Z} + \frac{\cos \theta}{A}\right) \qquad (1)$$

For a section not symmetrical with respect to the neutral axis, the greatest stress might happen to occur at point f, in which case the unit stresses at both e and f must be questioned.

Let S_1 = the greatest combined unit stress at f,
T = the unit tensile stress due to R, and
a = the unit compressive stress due to N.

Then

$$S_1 = T - a,$$

$$T = \frac{RL}{Z}$$

where Z = section modulus of that part of the section under consideration. In sections symmetrical with respect to the neutral axis, values of Z are alike for both the tensile and compressive sections.

As before,

$$a = \frac{N}{A}$$

Then

$$S_1 = \frac{RL}{Z} - \frac{N}{A}$$

Substituting values of R and N:

$$S_1 = P\left(\frac{L \sin \theta}{Z} - \frac{\cos \theta}{A}\right) \qquad (2)$$

For example, in Fig. 1, let $P = 10{,}000$ pounds, $L = 60$ inches, and $\theta = 30$ degrees, with section as shown in Fig. 3. The material is cast iron.

This section, not being symmetrical with respect to the neutral axis, the unit stresses at both e and f must be found, to make certain that either does not exceed the elastic limit of the material, which for cast iron is about 6000 pounds in tension and 18,000 pounds in compression. Use Formulas (1)

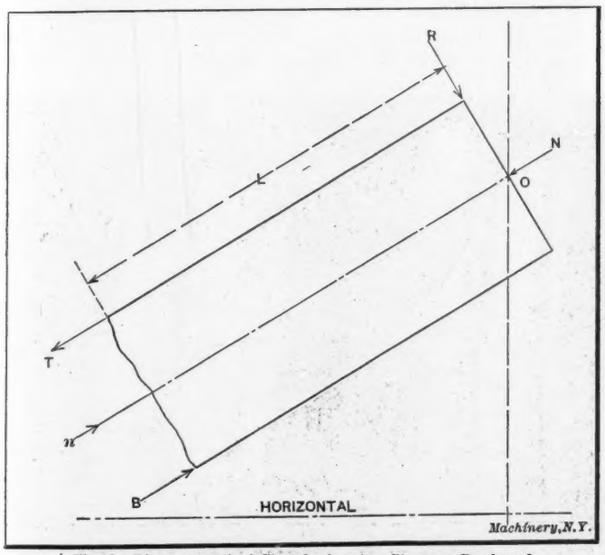


Fig. 2. Diagrammatical Sketch showing Stresses Produced

and (2) to find the unit stresses at e and f. Here Z, the section modulus, equals $\frac{I}{C}$ or $\frac{I}{C_1}$, where I = the moment of inertia of the entire section in Fig. 3, and C and C_1 = the distance in inches from the neutral axis to the outermost fiber of section under consideration. In this case either the shaded section is in tension due to R, or the legs of the channel not shaded are in compression due to R. Any one of the handbooks (say, "Cambria") gives A, C and C_1, I and Z in terms of the dimensions of the section.

For section, Fig. 3:

$A = b\,d - h\,(b - t) = (10 \times 16) - 14\,(10 - 1) = 34.$

$$C = \frac{2\,b^2\,s + h\,t^2}{2\,A} = \frac{(2 \times 100 \times 1) + (14 \times 1)}{2 \times 34} = 3.15$$

(for shaded section)

$C_1 = b - C = 10 - 3.15 = 6.85$ (for lower section).

$$I = \frac{2\,s\,b^3 + h\,t^3}{3} - A\,C^3 = \frac{(2 \times 1 \times 1000) + (14 \times 1)}{3} - (34 \times \overline{3.15}^3) = 334$$

$$Z \text{ for the shaded section} = \frac{I}{C} = \frac{334}{3.15} = 106$$

$$Z \text{ for the lower section} = \frac{I}{C_1} = \frac{334}{6.85} = 49$$

Using Formula (1) to find the unit stress at e,

$$S = P\left(\frac{L \sin \theta}{Z} + \frac{\cos \theta}{A}\right)$$

where $P = 10{,}000$,
$L = 60$,
$\sin \theta = 0.5$,
$\cos \theta = 0.866$,
$Z = 49$,
$A = 34$.

$$\text{Then } S = 10{,}000\left(\frac{60 \times 0.5}{49} + \frac{0.866}{34}\right)$$

or $S = 6380$ pounds unit compressive stress, which is well within the elastic limit of cast iron in compression.

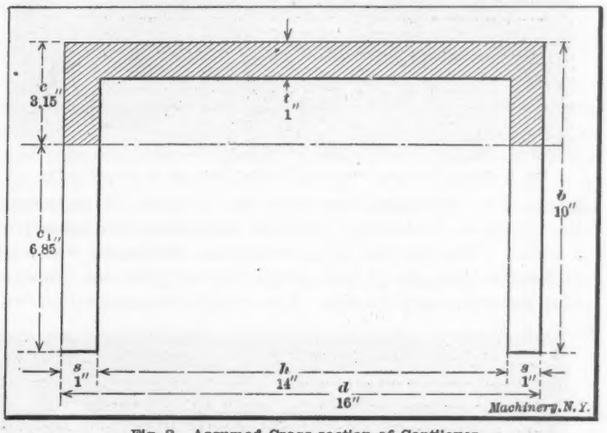


Fig. 3. Assumed Cross-section of Cantilever

Using Formula (2) to find unit stress of f,

$$S_1 = P\left(\frac{L \sin \theta}{Z} - \frac{\cos \theta}{A}\right)$$

The letter values are the same as in (1) excepting Z, which was found for this side of the section to be 106.

$$\text{Then } S_1 = 10{,}000\left(\frac{60 \times 0.5}{106} - \frac{0.866}{34}\right)$$

or $S_1 = 2575$ pounds unit tensile strength at f, which is well within the elastic limit of cast iron in tension.

* * *

AIR REQUIRED FOR PNEUMATIC HOISTS

The table below, taken from the *Industrial Engineering and Engineering Digest*, and compiled from curves in the 1910 catalogue of the Chicago Pneumatic Tool Co., gives the theoretical amount of free air used per foot when lifting maximum loads under various pressures for different sizes of hoists. In practice, 15 per cent should be added to the values given, in order to cover the losses.

CUBIC FEET OF AIR REQUIRED PER FOOT OF LIFT

Diam. of Hoist Cylinder, Inches	60 Pounds Pressure	80 Pounds Pressure	100 Pounds Pressure
4	0.5	0.6	0.75
6	1.0	1.25	1.60
8	1.75	2.25	2.75
10	2.75	3.50	4.25
12	4.00	5.00	6.00
14	5.30	6.80	8.40
16	7.00	9.00	10.80
20	11.00	14.00	17.00
24	16.00	20.25	24.50

METHOD OF HANDLING BOILER TUBES IN THE CANADIAN PACIFIC SHOPS

In the arrangement of one of the Canadian Pacific Railway repair plants, the tube shop is placed at a considerable distance from the erecting shop where the tubes are placed in the boiler. Owing to this location, considerable difficulty was experienced in handling the tubes and there was a loss of time in moving them from one shop to another. In order to remedy this difficulty the management decided to construct trucks for conveying the tubes and stands for supporting the trucks in a convenient position when removing tubes from a boiler. The material from which this equipment was made is mostly sheet metal and angle iron so that the construction is simple and durable. The trucks, in conjunction with the traveling cranes, greatly facilitate the handling of the tubes, which are systematically arranged so that those from a locomotive are kept together and handled as a unit.

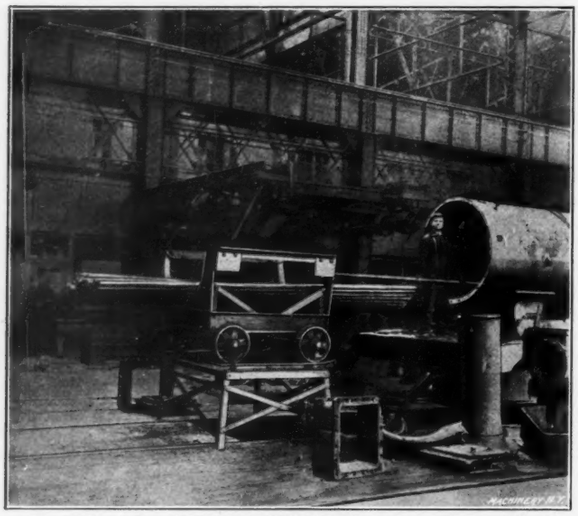


Fig. 1. Removing the Tubes and Placing them on an Elevated Truck

Fig. 2. Method of Storing Tubes

In Fig. 1, of the accompanying illustrations, the stripping gang is shown at work removing the tubes. These tubes are placed upon a truck that is mounted on a stand designed especially for that purpose, the truck being practically on the same level as the boiler. The shafting seen in the background of this illustration, while having no relationship to the subject of this description, is of interest as it operates two drills, two small planers for machining shoes and wedges, and a threading machine; there is also a blacksmith's forge. All of this apparatus is used for the erecting shop only.

Fig. 5 shows how the tubes are transferred from one of the trucks to the tube rumbler. The operation of this rumbler, which is made by Joseph T. Ryerson & Sons, Chicago, Ill., is very simple. The tubes, which are supported by two wide endless chains driven by sprocket wheels, are lowered by lengthening the chains into a pit or tank (seen beneath the truck) which contains water. When the tubes are immersed, they are rolled around by the operation of the chain loops and this continuous rolling movement removes the scale. One of the advantages of this rumbler, over the type commonly used, is in the elimination of practically all noise. This operation requires on an average of from 10 to 48 hours for cleaning about 300 tubes, the variation in time depending upon their condition.

Fig. 3. The Tube Welding Department

Fig. 3 shows a general view of the shop. In the left foreground is the tube cutter, and to the right of this a mechanic may be seen working at a tube welding machine, which has a capacity of about 200 tubes per day when operated by an expert. At the right of the illustration can be seen the forges for heating the tubes. Fig. 4 shows the manner in which the tubes are placed so that they can be conveniently handled by the workmen. It will be noticed that a truck containing a

set of tubes has been lowered into a pit to bring the tubes to the most convenient level. The rumbler, which is enclosed in a box-like structure, may be seen in the background. Fig. 2 illustrates the method of storing the tubes. As the engraving shows the trucks are stacked one upon the other, thus enabling a large number of tubes to be stored in a comparatively small space. This illustration also shows a tube cutter.

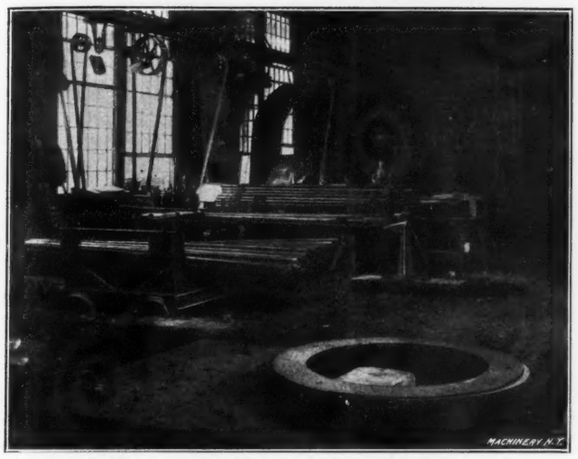


Fig. 4. Another View of the Tube Department

All the consignments of tubes are closely inspected and a tube is selected at random from every hundred and subjected to the following physical tests:

A longitudinal section or strip 1/2 inch wide by 6 inches long is heated to a cherry red and plunged into a water bath having a temperature of 50 degrees Fahrenheit. The piece is

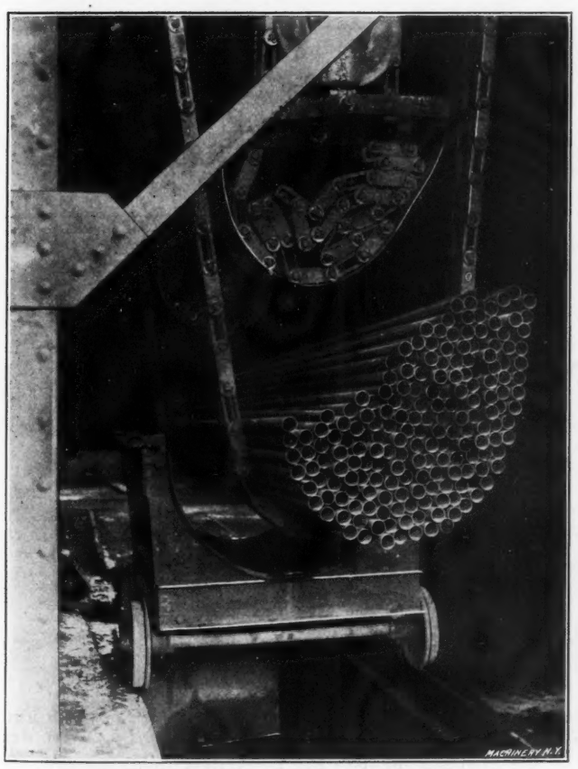


Fig. 5. Removing Tubes from the Rumbler

then doubled upon itself and hammered flat. This must be accomplished without cracking the material. The heating is for the purpose of checking the carbon content.

Another section of the tube having a length equal to one-half the diameter, is placed vertically on an anvil and subjected to a series of light blows. This piece must also crush flat without cracking. A section 6 inches long must not crack when flattened cold on itself, even though the weld forms one edge. A section having a length of 2 inches must not crack when a ⅜-inch flange is formed at right angles to the tube.

THE EFFECT OF KEYWAYS ON THE STRENGTH OF SHAFTS*

The strength and the proper proportioning of keys have been subjects of considerable study and of some experimentation, but the effect of the keyway on the torsional strength of the shaft has apparently been studied but little. Evidently, the keyway must weaken the shaft in which it is cut. In view of the very effective use of shafts with keyways, and the small amount of information available on the subject, the effect of keyways on the torsional strength of shafts has seemed to the author a problem worthy of some experimental study. The following is an account of an investigation carried on in the Laboratory of Applied Mechanics by the Engineering Experiment Station of the University of Illinois.

The mathematical analysis of the strength of a shaft with a keyway cut in it is a problem of great complexity. So far as the writer knows, there has been no successful attempt to develop the mathematical theory of the stress in a shaft with a keyway cut in it. However, as the range of sizes of shafts and keys in common use is not very great, it was thought that an experimental study of the effect of keyways on the strength of shafts might lead to formulas which may be safely used in nearly all the cases met with by the designer of shafts and keys. A considerable part of the experimental work was performed by F. E. Leidendeker, class of 1908, and O. Craig and J. C. Lund, class of 1909, senior students of the College of Engineering of the University of Illinois.

Adopting a nomenclature similar to that used by many writers on the strength of riveted joints, the ratio of the strength of a shaft with a keyway to the strength of a similar shaft without a keyway is hereafter spoken of as the *efficiency* of the shaft with keyway. The elastic limit of a shaft under torsion is taken as the measure of its strength.

The following notation is used:

d = actual diameter of shaft in inches,
w = width of keyway divided by diameter of shaft,
h = depth of keyway divided by diameter of shaft,
T = torsional (twisting) moment on shaft in inch-pounds,
M = bending moment on shaft in inch-pounds,
J = polar moment of inertia of cross-section of shaft $\left(\text{for circular shaft, } J = \frac{d^4}{10.2}\right)$
f = greatest fiber stress in shaft due to torsion,
α = angle of twist of shaft in degrees,
l = length of shaft in inches,
E_s = modulus of elasticity of material of shaft in shear (torsion),
e = efficiency of shaft with keyway,
k = ratio of angle of twist of shaft with keyway to angle of twist of similar uncut shaft,
H. P. = horsepower,
R. P. M. = number of revolutions per minute.

The following formulas are used:

$$T = \frac{2fJ}{d}$$

$$\alpha = \frac{2fl}{E_s d} \times 57.3$$

$$T = 63{,}020 \frac{\text{H.P.}}{\text{R.P. M.}}$$

The first two formulas are based on the following assumptions: 1. That a plane section of the shaft remains plane during torsion; 2. That the fiber stress varies uniformly from zero at the axis of the shaft to a maximum at the outer fiber, *i. e.*, the modulus of elasticity for shear remains constant. The first assumption is not true for shafts which are not circular in cross-section.

* Abstract from Bulletin No. 42, of the Engineering Experiment Station, University of Illinois, Urbana, Ill. Herbert F. Moore, assistant professor of theoretical and applied mechanics, is the author of the bulletin.

Test Pieces, Tests, and Method of Testing

As nearly all shafting in common use is cold-rolled, the principal series of tests was made on specimens of cold-rolled steel shafting. The diameters of the test shafts of these series were 1 1/4, 1 9/16, 1 15/16, and 2 1/4 inches. Shafts were tested under simple torsion and under torsion combined with bending. The bending moment applied to the shaft was in one case equal to the torsional moment, and in another equal to three-fifths of the torsional moment.

For transmitting power, it is common American practice to use a square key whose width and depth are each equal to about one-fourth the diameter of the shaft (Kent's Mechanical Engineer's Pocket-Book, pages 975 and 976). This means a keyway in the shaft in which $w = 0.25$ and $h = 0.125$. The depth of keyway is measured as shown in Fig. 1.

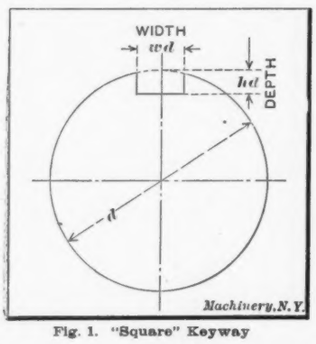


Fig. 1. "Square" Keyway

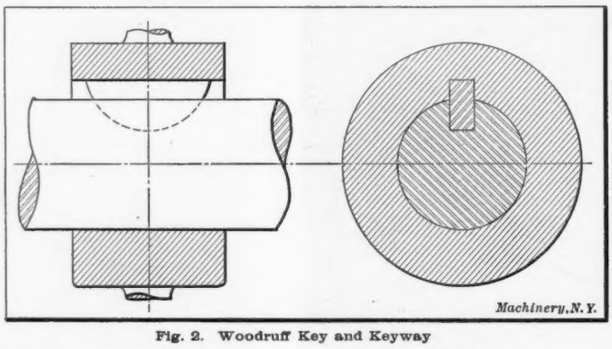


Fig. 2. Woodruff Key and Keyway

Shafts were also tested with keyways for the Woodruff system of keying. The outline of the Woodruff key and its keyway is shown in Fig. 2. In choosing the sizes of Woodruff keyways to be cut in the test shafts, the shearing strengths of various standard sizes of keys were calculated, and a standard size was chosen such that the shearing strength of two keys equaled, as nearly as possible, the torsional strength of the solid test shaft in question. The sizes of the Woodruff keys chosen are shown in Tables I and II.

In addition to the above tests for the effect of single keyways on the strength of cold-rolled shafting, tests were made which yielded data on the following subjects: ultimate strength of shafts with keyways; effect of two keyways at right angles; effect of length of keyway; effect of keyways on turned steel shafting. All keyways, except in the tests for studying the effect of length of keyways, were cut to a length equal to about four times the diameter of the shaft, no keyway being longer than eight inches.

All material for the test shafts was bought in the open market. Both the cold-rolled and the turned shafting were of ordinary soft steel. With a very few exceptions, all tests were made in duplicate. All shafts tested under simple twisting were tested in the 230,000-inch-pound Olsen torsion testing machine.

Data and Results

Table I shows the results of tests to breaking, of shafts with and without keyways. It seems that a shaft with a single keyway of common dimensions has about the same ultimate strength as a shaft without a keyway. In the torsional tests to destruction, after the elastic limit of the shaft had been passed, the keyways gradually closed up and at rupture they were entirely closed. The larger keyways and the two keyways 90 degrees apart lowered the ultimate strength somewhat. The variation in strength due to difference in material of the shafting seems to cause more variation in ultimate strength than is caused by different keyways. The elastic limit of a shaft is more significant than its ultimate strength.

While, as mentioned, the keyways in nearly all the shafts tested were cut to a total length of about four times the diameter of the shaft, no keyway being longer than eight inches, in several special shafts keyways were cut eighteen inches long. No difference between the *strength* of shafts with long keyways and that of similar shafts with the usual shorter keyways was observed.

One test was made of a shaft having two keyways 90 degrees apart cut in it, the two keyways being located in the same cross-section of the shaft. While the result of this single test is by no means conclusive, it is of interest to note that the reduction in strength at the elastic limit of the shaft by these two keyways was nearly three times as great as the reduction in strength at the elastic limit of a similar shaft by one such keyway.

The tests made were mainly on cold-rolled shafting, but a few tests were made on test specimens of turned shafting. These results must be regarded as tentative. In these tests the effect of keyways on the strength of turned shafting at the elastic limit seemed to be about the same as the effect of keyways on the strength of cold-rolled shafting.

During the tests, the question arose as to the difference in strength of a shaft with an empty keyway and a shaft on which a pulley was keyed in place, the key nearly filling the keyway. It was judged best, however, to test shafts with empty keyways, as there is usually a part of the keyway at either end not filled by the key, and a perfect fit of the key in the keyway is by no means certain, especially after long service and, therefore, for purposes of design the empty keyway determines the strength of the shaft.

TABLE I. ULTIMATE STRENGTH OF SHAFTS WITH AND WITHOUT KEYWAYS

Values are the average results of two tests.

Diameter of Shaft	Keyway		Maximum Twisting Moment, Inch-pounds	Maximum Computed Fiber Stress (solid shaft) Pounds per Square Inch	H.P. 100 R. P. M.	Remarks
	Width, Inches	Depth, Inches				
1¼ inch, cold-rolled	0	0	27,400	70,550	43.4	Shaft without keyway
	1/4	1/4	27,600	71,000	43.8	
	3/8	1/4	30,300	78,000	48.0	
	1/4	3/8	24,400	63,000	38.7	
	1/4	1/8	27,600	71,000	43.8	
	3/8	1/8	27,200	70,000	43.1	
	No. 10	No. 10	25,500	65,800	40.4	Keyway for No. 10 Woodruff
	No. 15	No. 15	26,200	67,600	41.6	Keyway for No. 15 Woodruff
	1/4	1/4	25,300	65,200	40.1	2 keyways 90 deg. apart
1¼ inch, turned	0	0	25,300	65,200	40.1	Shaft without keyway
	1/4	1/4	25,800	66,400	40.9	
	1/4	3/8	25,500	65,700	40.4	
	No. 10	No. 10	23,700	61,000	37.6	Keyway for No. 10 Woodruff
	No. 15	No. 15	24,100	62,100	38.2	Keyway for No. 15 Woodruff
1⅝ inch, cold-rolled	0	0	54,700	65,000	86.8	Shaft without keyway
	11/32	11/64	56,400	67,000	89.6	
2 inches, cold-rolled	0	0	103,700	66,000	164.5	Shaft without keyway
	7/16	7/32	102,100	65,000	162.0	
	7/16	7/16	101,500	64,600	161.1	
	7/16	9/16	94,200	60,000	149.1	
	9/16	7/32	104,500	66,500	165.7	
	No. 16	No. 16	105,300	67,000	167.0	Keyway for No. 16 Woodruff
	No. 21	No. 21	100,500	64,000	158.7	Keyway for No. 21 Woodruff
2 inches, turned	0	0	100,500	64,000	158.7	Shaft without keyway
	7/16	7/32	94,200	60,000	149.1	
	9/16	7/32	94,200	60,000	149.1	
	No. 16	No. 16	89,800	57,200	142 5	Keyway for No. 16 Woodruff
	No. 21	No. 21	85,000	54,100	134.8	Keyway for No. 21 Woodruff

The amount of twist in a shaft transmitting power is frequently of importance. Table III gives the ratio of angle of twist of shafts with keyways to angle of twist of shafts without keyways as computed from the data of the torsional tests for stresses within the elastic limit. The results are fairly well represented by the equation

$$k = 1.0 + 0.4\,w + 0.7\,h,$$

in which

k = ratio of angle of twist of shaft with keyway to angle of twist of similar shaft without keyway,

w = width of keyway divided by diameter of shaft,

h = depth of keyway divided by diameter of shaft.

Keyways for two Woodruff keys of shearing strength sufficient to develop the full twisting strength of shaft seemed to reduce the stiffness of the shaft somewhat less than did a keyway for a square key whose side measures one-fourth the diameter of the shaft. In considering the torsional stiffness of a shaft, it must be remembered that the keyways reduce the stiffness only over that portion of length which they actually occupy.

TABLE II. EFFICIENCY OF SHAFTS WITH KEYWAYS

$$\text{Efficiency} = \frac{\text{elastic strength of shaft with keyway}}{\text{elastic strength of shaft without keyway}}$$

Dimensions of Keyway	w = 0.50 h = 0.125	w = 0.25 h = 0.1875	w = 0.25 h = 0.125	Woodruff System*
Under simple torsion:				
Cold-rolled shaft, dia. 1¼ inch	0.762	0.760	0.820	0.840
Cold-rolled shaft, dia. 1 9/16 inch	0.803	0.846	0.900	0.860
	0.758	0.817	0.889	0.815
Cold-rolled shaft, dia. 1 11/16 inch	0.748	0.710	0.860	0.826
	0.764	0.750	0.824	0.835
Cold-rolled shaft, dia. 2¼ inch	0.848	0.775	0.839	0.943
	0.705	0.689	0.825	0.861
Under combined torsion and bending:				
1. Twisting moment = Bending moment	0.630	0.636	0.791	0.716
Cold-rolled shaft, dia. 1¼ inch	0.680	0.698	0.803	0.750
Cold-rolled shaft, dia. 1 11/16 inch	0.584	0.697	0.854	0.858
	0.671	0.775	.....	0.840
2. Twisting moment = ⅝ Bending moment	0.895	0.670	0.940	0.930
Cold-rolled shaft, dia. 1¼ inch	0.870	0.735	0.888	0.880
Cold-rolled shaft, dia. 1 5/16 inch	0.740	.....	0.832	0.856
	0.815	.....	0.840	0.810
General Average	0.752	0.735	0.850	0.845

* In 1¼-inch shafts keyways were cut for No. 15 Woodruff keys; 1 9/16-inch shafts keyways were cut for No. 25 Woodruff keys; 1 11/16-inch shafts keyways were cut for No. S Woodruff keys; 2¼-inch shafts keyways were cut for No. U Woodruff keys.

Efficiency of Shafts with Keyways

The efficiency of a shaft with keyway has already been defined as the ratio of strength at elastic limit of a shaft with keyway to the strength at elastic limit of a similar shaft without keyway. Table II shows the efficiency of the various test shafts. From this table it would appear that for a set of shafts of different sizes having the dimensions of the keyway kept proportional to the diameter of shaft, the efficiency does not depend, to any noticeable degree, on the size of shaft. The efficiency does not seem to be affected by the addition of a bending moment as great as the twisting moment. The efficiency of a shaft with two keyways cut in the same plane for two Woodruff keys, of such size that the strength of the solid shaft was equal to the shearing strength of the two Woodruff keys is about the same as the efficiency of a shaft with a keyway whose width equals one-fourth the diameter of the shaft and whose depth equals one-eighth the diameter of the shaft.

TABLE III. RATIO OF ANGLE OF TWIST OF SHAFT WITH KEYWAY TO ANGLE OF TWIST OF SIMILAR SHAFT WITHOUT KEYWAY

Diameter of Shaft, Inches	Dimensions of Keyway			
	w = 0.25 h = 0.125	w = 0.25 h = 0.1875	w = 0.50 h = 0.125	Woodruff System*
1¼	1.24	1.25	1.27	1.11
1 9/16	1.14	1.24	1.19	1.11
	1.18	1.21	1.36	1.18
1 11/16	1.16	1.21	1.41	1.11
	1.29	1.48	1.54	1.12
2¼	1.10	1.25	1.18	1.05
	1.10	1.28	1.37	1.10
Average	1.17	1.27	1.33	1.11

* See Table II for sizes of Woodruff keyways

The results of the foregoing tests are fairly well represented by the equation

$$e = 1.0 - 0.2\,w - 1.1\,h, \text{ in which}$$

e = efficiency of shaft with keyway,

w = width of keyway divided by diameter of shaft,

h = depth of keyway divided by diameter of shaft.

This equation gives efficiencies slightly lower than those observed for keyways of small width or depth, and efficiencies about the same as those observed for keyways in which $w = 0.50$ and $h = 0.125$; or $w = 0.25$ and $h = 0.1875$. As this equation is entirely dependent on the results of experiments, it should not be used for points much outside the limits of the experiments. The limits of the above series of tests were keyways having $w = 0.50$ and $h = 0.1875$.

Fig. 3 affords a convenient graphical method of applying the above formula, and is used as follows: To determine the efficiency of a shaft with a given (or proposed) keyway, locate on the diagram a point whose vertical distance from 0 equals the value of h, and whose horizontal distance from 0 equals the value of w. This point will, in general, fall between two lines representing values of efficiency, and the efficiency of the shaft in question may then be estimated with sufficient accuracy. The space within the triangle OAB represents the range covered by the tests actually performed, and covers the proportions of keyways commonly used in practice.

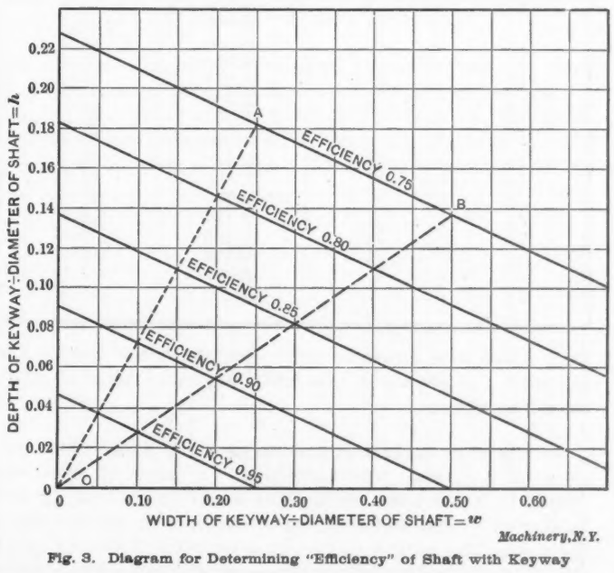


Fig. 3. Diagram for Determining "Efficiency" of Shaft with Keyway

Torsional Strength of Shafts with Keyways

The object of these tests was to determine ratios of strength and stiffness between shafts with keyways and shafts without keyways. The number of tests was not sufficient to give very much information as to the properties of cold-rolled steel shafting. However, as a matter of general interest, the values found in these tests for the modulus of elasticity in shear (torsion), and of the fiber stress at the elastic limit of the cold-rolled test shafts at sections without keyway, have been tabulated in Table IV.

Taking the fiber stress at the elastic limit of cold-rolled steel shafting at 37,500 pounds per square inch (a value slightly less than the average found in the tests), and the efficiency of shafts with keyways from the equation $e = 1.0 - 0.2\,w - 1.1\,h$, values for the twisting moments and the horsepower at 100

TABLE IV. MODULUS OF ELASTICITY IN SHEAR (TORSION) AND ELASTIC LIMIT IN TORSION OF COLD-ROLLED STEEL SHAFTING

Diameter of Shaft, Inches	Modulus of Elasticity	Fiber Stress, Pounds per Square Inch
1 1/4	12,900,000	43,300
1 9/16	12,000,000	36,800
1 9/16	12,490,000	38,500
1 15/16	10,800,000	36,800
1 15/16	12,660,000	40,500
2 1/4	11,340,000	36,200
2 1/4	11,710,000	40,500
Average	11,985,000	38,940

R.P.M., transmitted by cold-rolled shafts stressed to the elastic limit, have been computed for various sizes and tabulated in Table V. These values are for shafts with keyways for square

TABLE V. STRENGTH OF SHAFTS WITH KEYWAY

Diameter of Shaft, Inches	Side of Key, Inches	Twisting Moment, Inch-pounds	Horsepower at 100 R. P. M.
1	1/4	5,980	9.5
1 1/16	9/32	7,080	11.2
1 1/8	9/32	8,510	13.5
1 3/16	5/16	9,980	15.7
1 1/4	5/16	11,680	18.5
1 5/16	11/32	13,390	21.3
1 3/8	11/32	15,550	24.7
1 7/16	3/8	17,590	27.9
1 1/2	3/8	20,190	32.0
1 9/16	13/32	22,600	35.9
1 5/8	13/32	25,660	40.7
1 11/16	7/16	28,500	45.2
1 3/4	7/16	32,060	50.9
1 13/16	15/32	35,350	56.1
1 7/8	15/32	39,420	62.6
1 15/16	1/2	43,180	68.5
2	1/2	47,860	75.9
2 1/16	17/32	52,140	82.7
2 1/8	17/32	57,900	91.1
2 3/16	9/16	62,210	98.7
2 1/4	9/16	68,160	108.2
2 5/16	19/32	73,490	116.6
2 3/8	19/32	80,120	127.1
2 7/16	5/8	86,080	136.6
2 1/2	5/8	93,470	148.3

keys whose side measures about one-fourth the diameter of the shaft. In the use of this table, a suitable factor of safety should be allowed.

* * *

An amateur's method of making an index wheel which produced a fair result was as follows: A series of holes was drilled in a flat brass strip, using a simple drilling jig containing two holes and indexing from the hole just drilled to the next. The method was really a stepping-off process, using the drill and jig instead of a pair of dividers. The spacing of the holes was made so as to secure the desired number of holes in a circle of the approximate circumference wanted. For example, suppose 50 holes were required in a circle of 25 inches circumference (about 8 inches diameter). Then the spacing was made about ½ inch, and 51 holes were drilled in line in the strip. When the holes were drilled the ends of the strip were beveled to match at an angle of 45 degrees and the strip was evenly bent around a suitable mandrel to a circle. The bevels at the ends were cut through the two end holes slightly beyond their centers, and the ends were brought together and the drill or a plug of the same diameter was placed in the hole thus formed to locate the ends exactly the right distance apart. They were secured by solder and the complete ring was mounted in a wooden chuck and bored out. The wheel on which the index ring was to be mounted was turned to fit and the ring mounted in place.

A SYSTEM FOR LOCATING HEADS OF DEPARTMENTS

By VICTOR WHITE

It is often the case in large offices and other departments of engineering works that a draftsman is called away to some portion of the shop to get particulars for his work, or is called upon to make his appearance before the various departments connected with the drawing office. The same remark holds good to a considerable extent with other sections of the works organization, such as the cost department, the ordering and purchasing offices and the stores. During the absence of the man in charge of a particular piece of work, he may be required by someone else in the firm, and the course usually adopted is to leave a note on the vacant desk, asking the occupier on returning to communicate with the writer.

The method described is somewhat cumbersome and wasteful of time, so that a little device which has been brought into operation by one of our foremost engineering firms may be considered with interest. This consists of a form, as shown in the accompanying illustration, which is drawn on tracing cloth, and from which any number of blueprints can be made. These blueprints are then mounted on stiff cardboard, and holes punched in the card in positions as indicated in the illustration. The cards are then filled in with the names of the departments, and other members of the firm who need to be consulted from time to time, and small pegs having flat tops are made to fit these holes. Two of these pegs are provided for each card, one being plain on the top, the other being marked with the name of the department, and they are then used as follows:

Supposing that the draftsman has to go into, say, the milling shop, to see how a particular piece of work is being carried out: He takes the blank peg from its hole in the top of the card and places it in the column opposite the word "milling

Card used in Locating Heads of Various Departments

shop." Anyone coming along later and wishing to find this man will then see from the index that Mr. So-and-So is to be found in the milling shop. The use of the index peg is as follows:

Supposing that the man has left his post with the object of finding someone else: He takes with him the peg marked with the name of his department. Should the second person not be in his accustomed place, the first man puts the peg he has brought with him into one of the top holes of the card, and on the return of the second man he will find he is required by such-and-such a department. The rule is, then, that he must proceed at once to this department, carrying the peg back with him and must restore it to the man who has asked for him. In this way a perfectly simple and auto-

matic means for drawing the attention of one department to the requirements of another, is obtained.

In the case of head men or overseers whose duties involve a tour around the works, it is necessary to provide them with a series of pegs numbered consecutively. Before starting out from their office they then place the pegs in numerical order in the holes corresponding to the route which they intend to take. For example, the works manager may first of all wish to visit the drawing office, he may then proceed to the purchase department, to insure that goods are being ordered in accordance with drawings, then he may have something to say to the foreman of the pattern makers, and he may wind up his tour in the stores before returning to his own place. In this way he will put pegs numbered 1, 2, 3 and 4 opposite the various departments in their right order, so that any messenger boy who wishes to find him quickly will simply refer to the card and follow the same route. This system, although extremely simple, has been found to be of considerable time-saving value in cases where large numbers of departments have had to work together.

* * *

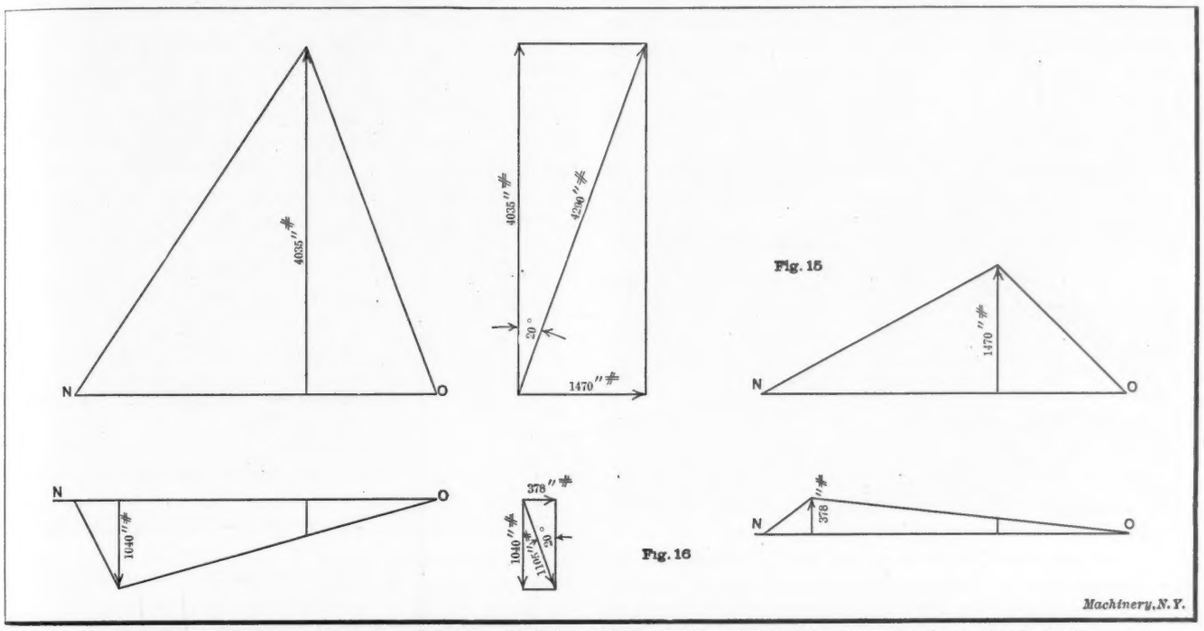
The tests carried out by the Stora Kopparoergs Bergslags Co. in Sweden with an experimental furnace for investigating the feasibility of electric iron smelting, have been successful, and a large electric smelting furnace is now being built. The company is planning to build ten of the new furnaces successively, each to have a capacity, at a low estimate, of 16,000 tons of pig iron a year. The power consumption will be about 40,000 horsepower, all the power required being generated at hydro-electric stations owned by the company.

DESIGN OF AUTOMOBILE TRANSMISSION GEARS*†—3

By M. TERRY‡

The preceding discussion of bearing pressures makes it clear that the secondary shaft is simultaneously subjected to two bending moments and a torque of 3080 inch-pounds. On intermediate, slow and reverse speeds, the torsional moment and one of the bending moments remain unchanged, while the second bending moment is determined by the speed. Since the greatest straining effort must be determined, it would first be necessary to solve three combinations of bending moments. The writer will limit his discussion to the slow speed, which, in the problem at hand, gives the greatest value of combined bending moments. The same method can be applied, of course, to the intermediate and reverse speeds. Since the distances between the bearings of the square and secondary shafts are the same, the bending moments on the two shafts at the center lines of gears D and H (Fig. 2) are the same, or 4290 inch-pounds (Table II). The second bending moment is equal to the reaction at N produced by pressure on gear B, multiplied by its distance from the center line of B, that is $1040 \times 1\,1/16 = 1105$ inch-pounds. (See December issue, page 268.)

Since any bending moment is located in the plane of the



Figs. 15 and 16. Bending Moments on Secondary Shaft due to Contact of D and H, and A and B, respectively, Resolved into their Vertical and Horizontal Vectorial Components

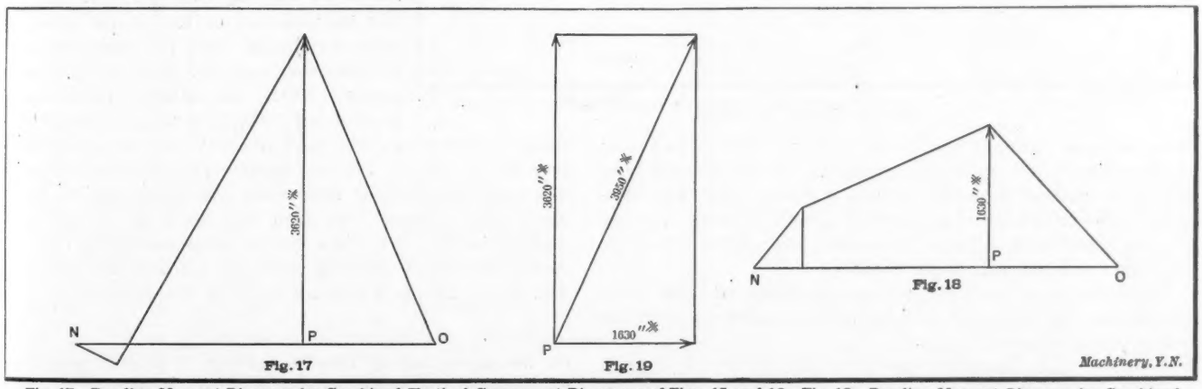


Fig. 17. Bending Moment Diagram for Combined Vertical Component Diagrams of Figs. 15 and 16. Fig. 18. Bending Moment Diagram for Combined Horizontal Component Diagrams of Figs. 15 and 16. Fig. 19. Maximum Vectorial Sum of Vertical and Horizontal Bending Moments

* This concludes the series of articles on this subject, previous installments of which appeared in the October and December numbers.

† An error appeared in the formula at the foot of the first column of the December installment of this article. Instead of

$$Te = zf = 0.200\ h^3$$

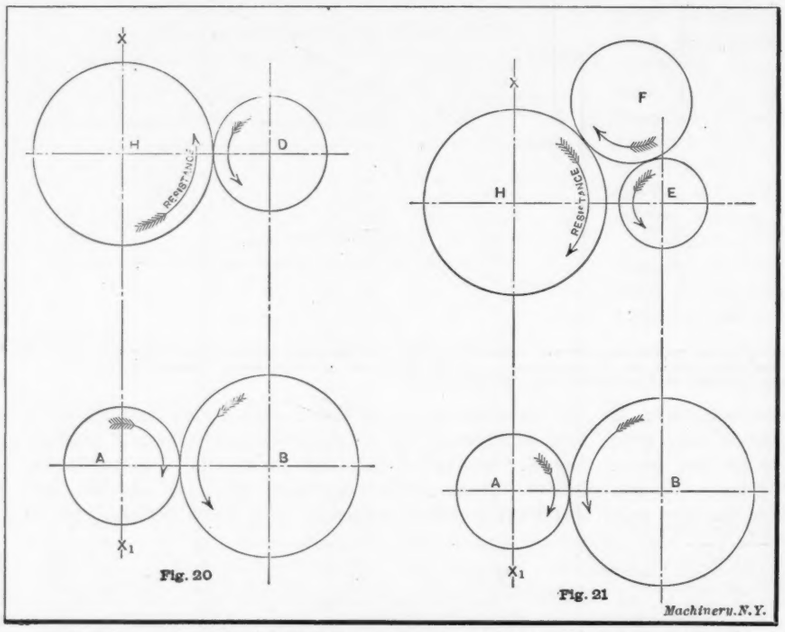
it should read

$$Te = zf = 0.200\ h^3 f.$$

‡ Address: 302 Williams St., Flint, Mich.

force producing it, it is clear at once, by referring to Fig. 10, that the said two moments are located in planes making an angle of 140 degrees with each other. The geometrical method for combining forces may also be applied to moments. This is shown in Figs. 15 and 16 where these two bending moments are resolved into vertical and horizontal components. Fig. 17 is the vectorial combination of the two vertical components shown in Figs. 15 and 16, while Fig. 18 is a similar combination of the horizontal components. These latter two figures are formed by adding vectorially the moments at any particular point on the shaft, the horizontal line representing that shaft. It will be noted that the vertical components are subtracted, while the horizontal ones are added. This is explained by the fact that the former act in opposite senses, while the latter act in the same sense. In reality, the moment diagrams of Figs. 17 and 18 are at an angle of 90 degrees with respect to each other. The resultant moment at any point on the secondary shaft can be represented by the hypotenuse of a right-angle triangle, whose legs are the moments at corresponding points of Figs. 17 and 18.

Those who are familiar with geometry can see at once that the maximum resultant moment is at P and is equal in extent to 3950 inch-pounds, as shown by Fig. 19. In some cases, however, it is impossible to determine at a glance where the maximum moment will occur and several triangles must, of necessity, be constructed before the location and magnitude of the maximum moment can be determined.



Figs. 20 and 21. Directions in which Transmission Box tends to rotate with Forward and Reverse Drives, respectively

Combining the resultant bending moment of 3950 inch-pounds with the torsional moment of 3080 inch-pounds by the previously mentioned formula,

$$T_e = M_b + \sqrt{M^2_b + M^2_t}$$

$T_e = 3950 + \sqrt{3950^2 + 3080^2} = 8960$ inch-pounds = equivalent torsional moment.

To find the diameter of the secondary shaft, solve for D in the following equation:

$$T_e = 0.196\, f\, D^3$$

which applies for a solid shaft; and, finally the diameter may be determined for a hollow shaft by the following formula:

$$T_e = 0.196\, f\, \frac{D^4 - d^4}{D}$$

where in both cases

D = the outside diameter of the shaft,

d = inside diameter of the hollow shaft,

f = safe unit stress.

For the case of a hollow shaft it is merely necessary to assume a desired size of hole for the shaft.

Support of Transmission Case

Any automobile transmission constitutes what is generally known as an "epicyclic train." At any given speed (direct drive excepted) the gears in active mesh form the "train" and the transmission box forms the "arm." By locking the arm, the forward and backward motion of the car becomes possible, for if the arm were not locked, that is in other words, if the transmission box were not laterally supported, the frictional resistance of the rear wheels resulting from contact with the ground, and the inertia of the car, would lock the last gear of the train (G or H) and spinning of the transmission box would be the result.

In Fig. 20, X-X, is the axis of longitudinal support. The driving torque of A tends to rotate the box clockwise about X-X, while the resisting torque of H produces a similar effect on the box in a counter-clockwise direction. The net effect on the box is the difference of the two on the slow speed. On the reverse, however, both the driving and resisting torques act in a clockwise manner with a net effect on the box of the sum of the two. This latter is shown in Fig. 21. From Table II we have the following:

On slow speed:

Torque on H = 5650 inch-pounds, counter-clockwise

Torque on A = 1680 inch-pounds, clockwise

Net torque = 3970 inch-pounds, counter-clockwise.

On reverse:

Torque on H = 7260 inch-pounds, clockwise

Torque on A = 1680 inch-pounds, clockwise

Net torque = 8940 inch-pounds, clockwise.

When the transmission is located next to the rear axle, as in E.M.F. and Overland cars, the transmission box is bolted to the bevel-gear housing, the bolts being usually located in a circle. Besides resisting the lateral torque of the box, these bolts are called upon to support the eccentric load caused by bearing pressures, and also to resist the moment of the torque tube. The same conditions, with the exception of the torque tube moment, exist in unit power plants. Where transmission constitutes an independent unit it is usually bolted to the frame or sub-frame, and the bolts may then be either in tension or in shear. Various departures and modifications of the above methods of supporting transmissions are in use, and it is necessary that each case be analyzed by the designer; but no matter how the transmission box is to be supported, provisions must be made for the lateral torque of the box, which has its maximum value on the reverse.

* * *

Considerable comment is made in the report for the year on the operations of Lloyd's register of British and foreign shipping on the advent of the internal combustion engine for marine propulsion, as it is becoming a question of immediate and practical importance. The Diesel oil engine is being fitted to three fairly large vessels, built on the continent under the supervision of the surveyors of Lloyd's register. These are of a new two-cycle type, capable of reversing and are, therefore, direct-connected. Producer gas engines are also being installed on vessels under Lloyd's supervision. The internal combustion engine for marine service is apparently here to stay.

* * *

The first world's aerial exhibition held at the Crystal Palace, London, England, from December 1 to January 31, promises to be the most important aeronautical exhibition held thus far. It will be divided into sixteen sections and will deal with the history of aeroplanes, balloons, and dirigibles, as well as with the present types.

AEROPLANES AND AIRSHIP ENGINES*

In France and America some of the most successful light gasoline engines have been designed for aviation service. A novel form of French aeroplane and airship motor is shown in the accompanying half-tone illustration Fig. 1, and line engravings Figs. 3 and 4. This engine is designed and constructed by the Société Mors, of Paris, France. It is constructed with four cylinders, arranged in pairs, with the cranks 180 degrees apart, each pair of cylinders being arranged in the form of a "V." The carburetor will be seen at the right, and the magneto, geared to the main engine shaft, at the left in the illustration. This French four-cylinder engine weighs only 97 kilograms (213 pounds), and develops 45 horsepower when operating at a speed of 1700 revolutions per minute.

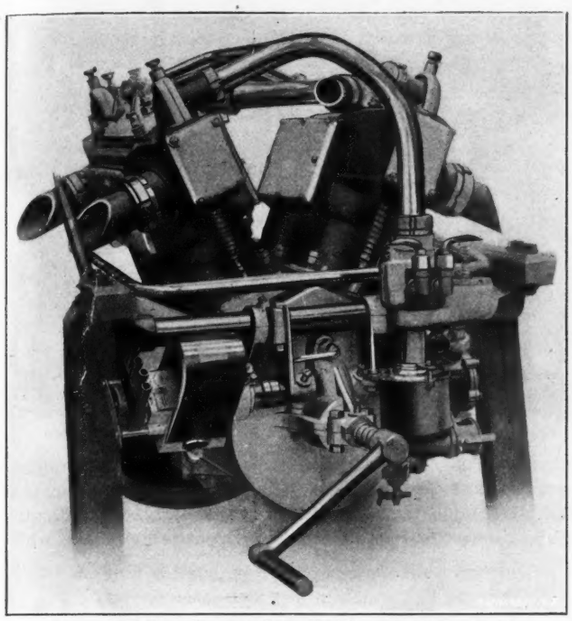


Fig. 1. Aeroplane Motor built by Societe Mors, Paris, France

An American motor for similar service is shown in Figs. 2 and 5. This is the Adams-Farwell gasoline engine, which was described in detail in MACHINERY, engineering edition, July, 1908. In this engine, gyroscopic force is utilized to steady the airship in its flight, the entire motor revolving around a stationary crankshaft. It is one of the lightest motors of its power ever constructed, weighing only 97¼ pounds and rated at 36 horsepower. It will be noted that this engine has no flywheel, no mufflers, and no cooling device, and the valves are closed by centrifugal force instead of by springs. There are ten valves actuated by a single cam, and the single-throw crankshaft weighs only 4½ pounds. For a more detailed description, reference should be made to the article previously published in MACHINERY, and mentioned above.

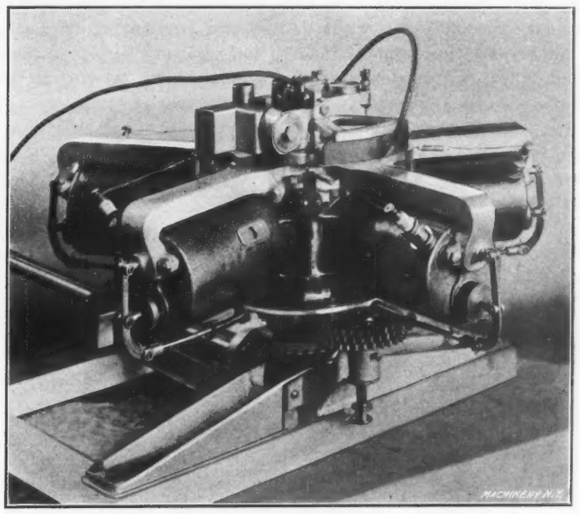


Fig. 2. The Adams-Farwell Aeroplane Motor

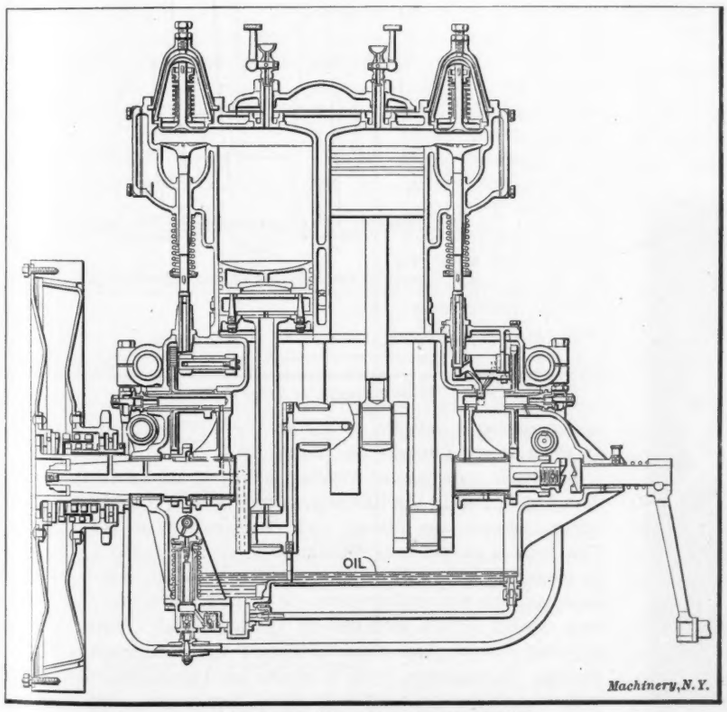


Fig. 3. Section of Mors Aviation Motor

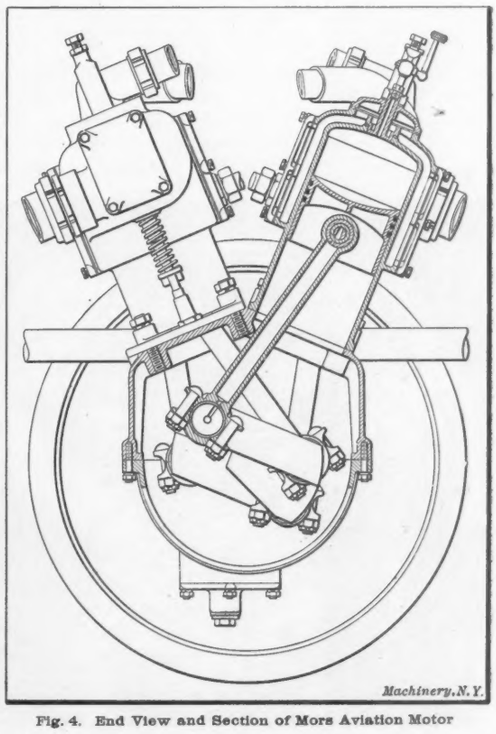


Fig. 4. End View and Section of Mors Aviation Motor

The principle advantage of this design is, of course, the feature of perfect air cooling, regardless of all external conditions, and independent of any auxiliary cooling devices. The revolving cylinders are, in effect, superior to a cooling fan, in that the radial cylinders act as blades of a centrifugal blower and discharge air in a direction tangent to their outer circle instead of parallel to their axis as would be the case

* For additional articles on this and kindred subjects, see MACHINERY, April, 1910, engineering edition, "Suggestions in the Design of Aeronautic Motors", "New Rotary Gas Engine for Aerial Navigation", "Light and Reliable Gas Engines"; November, 1909, engineering edition, "Light Aeronautic Motors"; October, 1909, engineering edition, "Glenn H. Curtiss—The Man, the Aeroplane and the Motor"; July, 1908, engineering edition, "Adams-Farwell Aeronautic Gasoline Motor."

with a fan. The air attains its highest velocity at the extreme outer end of the cylinders, which part requires the greatest cooling effect. The valves are located in the heads of the cylinders where they also receive the maximum cooling effect.

A novel eight-cylinder motor of the water-cooled "V"-type, of American construction, is shown in Fig. 6, the cylinders being 90 degrees apart and 45 degrees from the vertical. This aviation motor operates at a speed of 1200 revolutions per minute and weighs 275 pounds, including the magneto and oiler, ready for operation. The cylinders have special aluminum alloy heads, being cast with the shell in one piece with the cast-iron cylinder walls. Only one carburetor is used to supply all the eight cylinders, and the lubrication is provided for by a forced-feed oil-pump, located in the bottom of

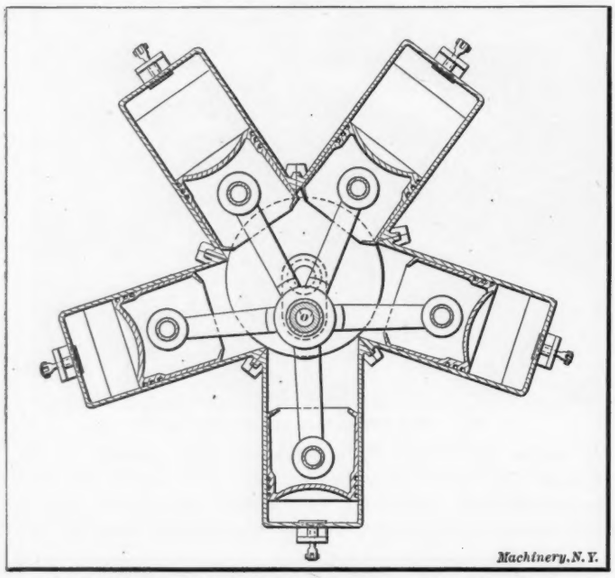


Fig. 5. Principle of Action of the Adams-Farwell Aeroplane Motor

the crank-case, operated by the crankshaft. The pistons are of gray cast iron, ground to size, while the crank-case is of a special aluminum alloy, fitted with bearings of phosphor-bronze. The valves are mechanically operated by one rod and overhead rocker-arms, with both valves in the head. The

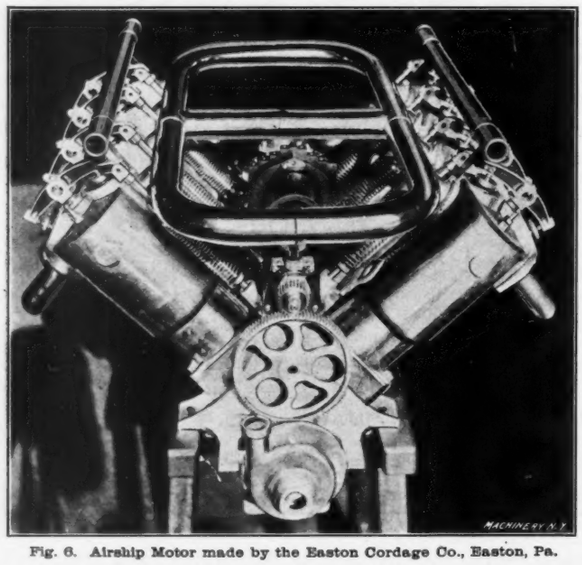


Fig. 6. Airship Motor made by the Easton Cordage Co., Easton, Pa.

crankshaft is 1½ inch in diameter, and made of chrome-nickel steel.

In examining the torque curves of four-, six- and eight-cylinder motors, it will be observed that the torque of a six-cylinder engine is considerably more than that of a four-cylinder, while the eight-cylinder shows none of the erratic qualities of the four-cylinder motor, and is far more steady than the six-cylinder. In fact, the pull all around the circle is about as perfect as can be obtained by the present gas engine. When eight cylinders are used, the power is not only more evenly divided, but considerable weight is saved, which could not possibly be dispensed with were a smaller number of cylinders employed. The eight separate cylinders of the

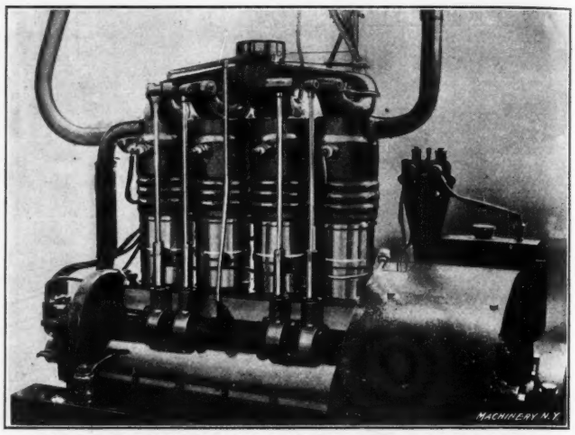


Fig. 7. Aerial Motor built by Panhard & Levassor, Paris, France

engine in Fig. 6 are arranged in two groups of four, on a common crank-case, the sets being at right angles to each other, and employing a four-throw crankshaft, each pin carrying the connecting-rods of a pair of opposite cylinders, which

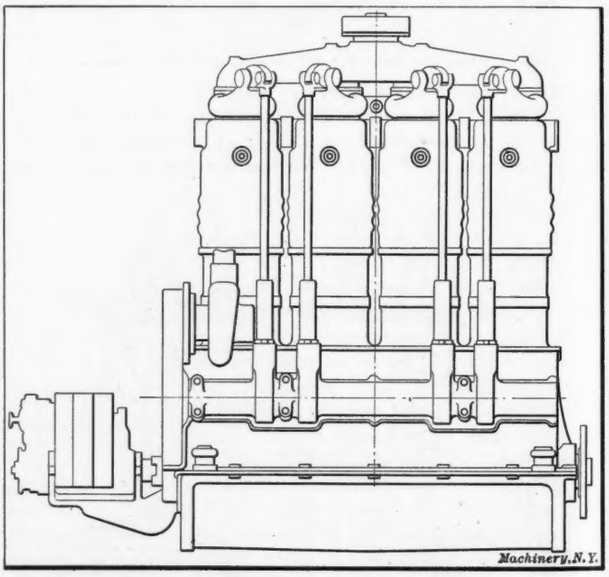


Fig. 8. Front Elevation of Motor shown in Fig. 7

are staggered in relation to one another. This engine is made by the Eastern Cordage Co., Easton, Pa.

A French water-cooled aviation motor is shown in the half-tone Fig. 7, and in the line engravings Figs. 8, 9, and 10, which latter indicate the design and construction of the engine. This type is designed by Panhard and Levassor, Paris, France. It measures 470 millimeters (18½ inches) in width at the base, and is 805 millimeters (31¾ inches) in height. The total length is 874 millimeters (34½ inches). This French gasoline engine has four cylinders 110 millimeters (4⅜ inches) in diameter with a stroke of 140 millimeters (5½ inches). It develops from 35 to 45 horsepower, and weighs, without the water utilized for cooling, about 95 kilograms (209 pounds). The arrangement of the valves, both exhaust and intake, as well as the ignition system, is clearly indicated in the illustrations.

Fig. 11 shows a recently brought out aerial engine of American design. This engine, built by David L. Herman, Detroit, Mich., is of the "V"-type, having eight cylinders. The reason that eight cylinders were decided on is that an engine with this number of cylinders gives continuous power with little

vibration. The hollow crankshaft which is made from Krupp's best grade of crucible chrome-nickel steel, has three line bearings of die-cast, cadmium-nickel bronze, which material is also used for the piston-pin bearings in the piston. One of the patented features, and one which makes this motor unique, is the single cam-shaft of one-piece construction, hardened and ground. This cam-shaft not only operates all the sixteen valves, but also drives the centrifugal pump, giving positive circulation. This construction eliminates thirty-six moving parts, and also eliminates all pins, etc., which are likely to work loose and cause trouble. The cam-shaft gear is of alloy steel, running into an intermediate fiber-filled gear,

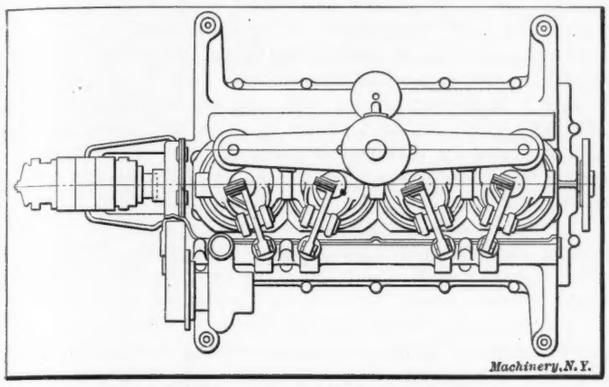


Fig. 9. View from Above of Motor shown in Fig. 7

thereby making a light, and at the same time a silent, train of gears. The valve tappets are hardened and ground, having fiber inserts. Another special feature is that the valves have gray cast-iron heads fused on steel stems, which not only makes it impossible for them to wear loose, but also gives a valve head of a material which has the same expansion as the iron of the cylinder, thereby eliminating the breaking of valves.

"Aerial metal," which is produced by the A. B. C. Castings Co., of Cleveland, Ohio, and which is fully fifteen per cent lighter than aluminum and 50 per cent stronger, is used not only for the crank-case, but also for the water jackets, pipes, gear housings, and in fact wherever a light alloy could be used without jeopardizing the serviceable properties of the motor. The crank-case has spacious hand-holes which make the connecting-rod bearings accessible. The water jacket being cast separate from the cylinder, makes it possible to thoroughly inspect the iron cylinder castings in a way that could not otherwise be attempted. These jackets are not shrunk on, but are bolted into position with chrome-nickel steel bolts in such a way that the difference of expansion between iron and "aerial metal" may be taken up in the bolt holes, so that, should a cylinder get hot, the water jacket does not crack. The oiling system is of the splash type, with force-feed oiler to the crank-case. The ignition system is of the high-tension type.

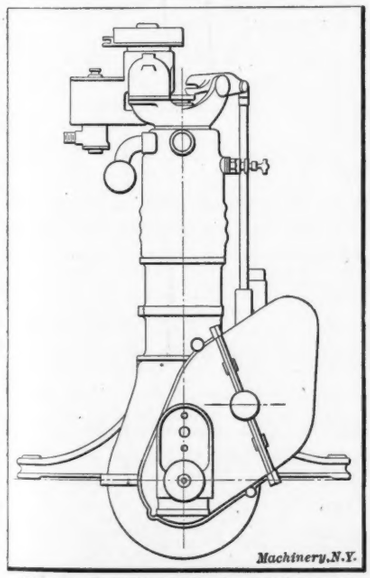


Fig. 10. End View of Panhard & Levassor Aerial Motor

The engines are built in two sizes; the smaller size has a stroke of 3⅜ inches, the bore being of the same dimension. It develops 45 horsepower at 1800 revolutions, and 34 horsepower at 1200 revolutions. Completely equipped, ready to run, it weighs 175 pounds. The hollow crankshaft is 1½ inch in diameter, the end bearings are 4½ inches long, and the center bearings 3 1/2 inches long. The pin bearings are 1 11/16 inch long, and the piston pin is ¾ inch in diameter. The valves are 1½ inch in diameter. This engine sells for $1750.

The large engine has a 4-inch bore and 4¾-inch stroke, and develops 70 horsepower at 1800 revolutions, and 56 horsepower at 1200 revolutions. When completely equipped and ready to run, it weighs 210 pounds. The hollow crankshaft is 1¾ inch in diameter, the end and center bearings are 4½ inches long, and the pin bearings, 2 inches long. The piston pin is hollow and ⅞ inch in diameter. The valves are 2 inches in diameter. This engine sells for $2500.

In order to prove the dependability of these engines, one of the smaller ones was mounted on an automobile truck and run over 5000 miles of rough roads. The truck was loaded with sand and pig iron. The engine required no repairs of any kind. The engine has been run under break tests for 72 hours without a stop, and at speeds as high as 4200 revolutions per minute.

Figs. 12 and 13 show an aeronautic engine made by the Aerial Navigation Co., Girard, Kan., known as the "Call aviation engine." Fig. 12 shows a two-cylinder and Fig. 13 a four-cylinder type. The engine is of the usual four-cycle type, water-cooled, 6 inches bore by 5¼ inches stroke; the two-cylinder engine develops 50 horsepower, and the four-cylinder engine, 100 horsepower, at 1750 revolutions per minute. The chief point of interest lies in the cylinder and cylinder head construction.

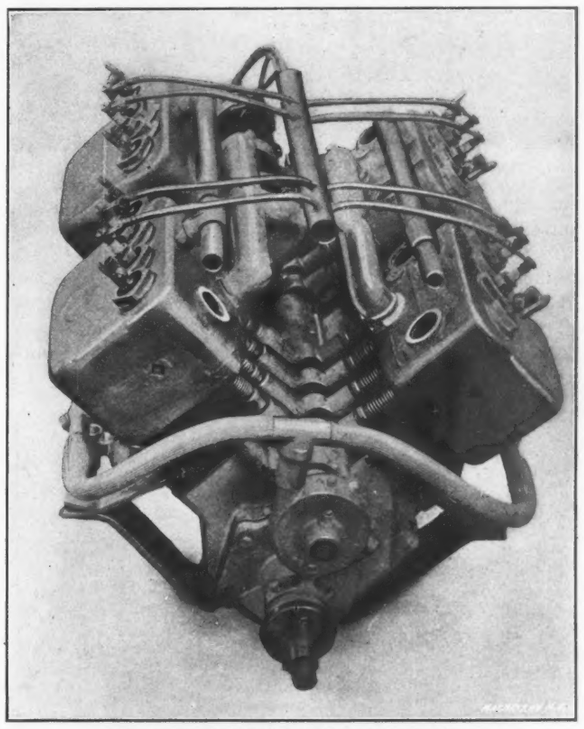


Fig. 11. An Aerial Motor of American Design

Even with the usual copper, or other sheet-metal, water jacket, adopted by most aeronautic engine manufacturers to lighten the weight of the cast-iron cylinders, the engine becomes unduly heavy. On the other hand, the employment of steel for cylinders, as has been attempted by certain manufacturers both in this country and in Europe, has not met with success. Engines of this construction, while giving satisfactory short runs, have failed in endurance tests. In the Call engine the cylinder walls, piston heads, valve cages, valve seats, and all other parts exposed to the heat of the explosion chamber, are constructed of vanadium gray iron, while the outer cylinders and cylinder heads, comprising also the water jacket, are constructed of an alloy of aluminum and magnesium, called magnalium.

Unlike other constructions in which the use of an outer cylinder of lighter metal with an inner cylinder or bushing of gray iron has been attempted, the iron inner bushing is surrounded throughout the entire explosion chamber length by the jacket water, without any intervening metal or joints, and no part of the lighter metal of which the outer cylinders and cylinder heads are composed, is exposed to the heat of the explosion chamber. With proper water circulation all danger of overheating the outer cylinders is thus avoided.

The gray iron bushings are machined to a fit, and are then pressed into the outer cylinder from the top. These bushings

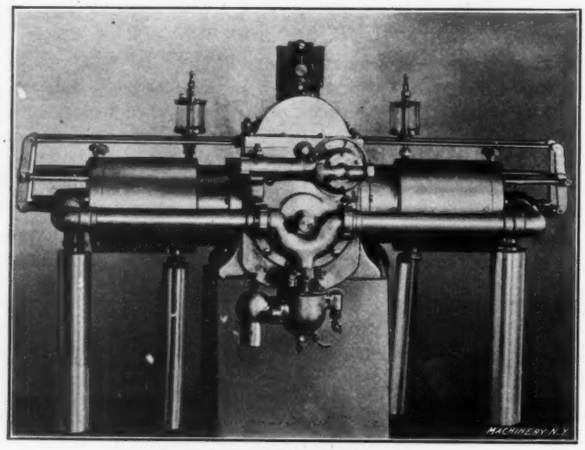


Fig. 12. Two-cylinder "Call" Engine

are of ample thickness throughout the length of the explosion chamber, and below that are considerably reduced in thickness. A shoulder upon the inner cylinder at the top is also machined to fit into a companion groove in the magnalium cylinder, in order to make a thoroughly water-tight connection, while the spiral partitions of the magnalium water jacket extend inward to the iron cylinder, thus greatly strengthening it. By the use of the lighter metal for the

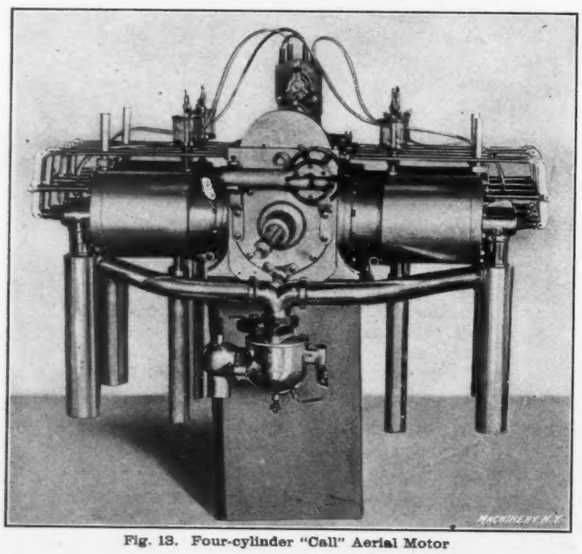


Fig. 13. Four-cylinder "Call" Aerial Motor

main outer cylinder, strength of construction results without undue weight.

In order to further lighten the engine, the valve cages, which are also of vanadium gray iron, are air-cooled above the level of the cylinder heads, while below this, and around the valve seats, they are water-cooled. The crank-case and fittings not exposed to the heat of the explosion chamber are also made of magnalium, and the crank-case is thoroughly braced and ribbed so as to give great strength with minimum weight. Having thus secured lightness in the heavier engine parts, there has been no attempt made to secure lightness by the use of insufficient sizes in the construction of piston heads, connecting-rods, crankshaft, and other like parts. The connecting-rods are of vanadium phosphor-bronze, and the crankshaft is of vanadium steel, solid throughout.

Both the inlet and exhaust valves are 2 inches in diameter, and the valve lift is ⅜ inch. In addition to the main exhaust valves, a ¾-inch (inside diameter) auxiliary exhaust port, water-cooled, is placed on the bottom side of each cylinder. This exhaust port is allowed to open somewhat in advance of the main port, and thus draws the fire, furnishing an additional safeguard against the overheating of the main exhaust valve seats and bearings. Both the main and exhaust ports are silenced, not by means of the usual baffle or muffler plates which crowd the exhaust back into the explosion chamber, but by a silencer constructed of an inner casing of steel tubing, with V-slotted mouth, over which an outer casing of aluminum tubing of considerably larger proportions is then fitted by means of a vanadium gray iron ring or thimble containing a large number of holes around its circumference. The force of the exhaust pumps the cold air through these openings, and by this means the gases are so cooled and shrunk by the time they reach the mouth of the silencer as to greatly diminish the noise so common in aviation motors.

The water jacket partitions are spirally arranged in such a manner that the jacket water passes four times around the cylinder during each circuit, and then over the entire surface of the cylinder heads. The engine is equipped with a piston circulating pump instead of the usual centrifugal or gear-pump adopted on automobiles and commonly used on aviation engines. This piston pump is positive in its action, and in connection with the spiral cooling flanges, forces the jacket water four times around the cylinders during each fifteen seconds.

The prices of the above engines are $1000 for the 50 horsepower, and $2000 for the 100 horsepower. The 100-horsepower motor complete, including oil and water pumps, carburetor, mufflers, and force-feed oiling system, weighs 350 pounds. The 50-horsepower motor complete, including water and oil pumps, carburetor, mufflers, etc., weighs 175 pounds. The weight of the magneto is not included in either of these figures.

* * *

"HORSEPOWER REQUIRED TO COMPRESS AIR"—CORRECTION

In the December, 1910, number of MACHINERY, engineering edition, page 288, a formula in the article entitled "Horsepower Required to Compress Air" is given as follows:

$$\text{H.P.} = \frac{144 \times P\,V}{33{,}000}\left(1 + \text{Nap. log.}\,\frac{P_3}{P}\right)$$

It will be noted that in the Data Sheet Supplement accompanying the December issue, the formula is given as follows:

$$\text{H.P.} = \frac{144\,P\,V}{33{,}000}\left(\text{Nap. log.}\,\frac{P_3}{P}\right)$$

This latter form is the correct form, as given by the author, and the erroneous expression on page 288 is due to a typographical error.

* * *

The electrification of main lines is progressing steadily, if not rapidly, abroad. The Medi Railway of France is to electrify 70 miles of road on the Toulouse-Bayonne line. It is planned to electrify later the whole of this line, a distance of 200 miles. This is the largest scale upon which electrification has as yet been undertaken in France, and the results will be watched with no little interest throughout Europe. The experiments which have been carried on in Germany during the last three years have been so successful that it has been resolved to introduce electric traction on several main lines. The electrification of the first section of the railway connecting Magdeburg, Leipsic and Halle will shortly be finished, and during 1911 work will be begun on the electrification of a line in Silesia, running through a very mountainous region. The electrification of the Lapland railway in Sweden, which is one of the most ambitious undertakings in railway electrification, was treated in detail in the October, 1910, issue of MACHINERY.

INS AND OUTS OF GEAR HOBBING

By RALPH E. FLANDERS*

The hobbing machine has produced quite a little stir in the gear-cutting business in the past five years. It is, to all outward appearances, one of the most attractive of the gear-cutting machines, particularly in the matter of output. Some of its backers have also claimed for it that it produces work of a high grade of commercial accuracy. This has always been questioned, however, and the reputation of the hobbing process, and of various machines employing that process, have been rather fluctuating in this respect.

The writer has long had the intention of carrying out a series of experiments which, if properly conducted, should give some definite information as to the accuracy of the hobbing process of cutting gears, and the reasons for what inaccuracies there might be. A few weeks ago, through the kindness of three friends who furnished blanks, a hob and a hobbing machine respectively, these experiments were carried out. While the results were not so conclusive as had been hoped for, they nevertheless do show some things of interest great enough to warrant their being placed on record.

The machine used was one which, in the opinion of the writer, is the best designed and most generally satisfactory of all the hobbing machines. The hob was made by a firm

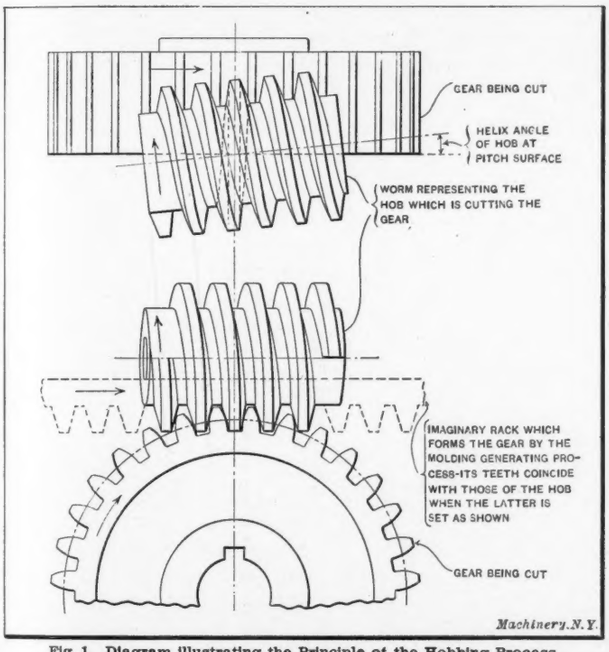

GEAR BEING CUT
HELIX ANGLE OF HOB AT PITCH SURFACE
WORM REPRESENTING THE HOB WHICH IS CUTTING THE GEAR
IMAGINARY RACK WHICH FORMS THE GEAR BY THE MOLDING GENERATING PROCESS-ITS TEETH COINCIDE WITH THOSE OF THE HOB WHEN THE LATTER IS SET AS SHOWN
GEAR BEING CUT
Machinery.N.Y.

Fig. 1. Diagram illustrating the Principle of the Hobbing Process of Generating Spur Gears

with a high reputation for such work, and presumably represented the best in American practice. It is not necessary to give the name of the manufacturer of either the hobbing machine or the hob, since this article is a discussion of principles, and not a comparison of the work of individual manufacturers.

The Principle of the Hobbing Process

While the principle of the hobbing process is generally understood, it may be advisable to review it briefly. In Fig. 1 is shown an imaginary rack meshing with a gear. If the gear were made from a plastic blank, rolling it with the rack would generate in it teeth of proper outline to mesh with the rack, or with any gear of the interchangeable system to which the rack belongs. The rack teeth (in dotted lines) coincide with the teeth of the worm (in full lines) which has been set at such an angle as to make the teeth on its lower side parallel with the axis of the gear. In other words, it has been set at the angle of its helix, measured at the pitch line. The teeth of the worm, then, when set in this position, correspond with the teeth of the rack. If now the gear and the worm be rotated together in the ratio required by the number of teeth in the gear, this will cause the teeth of the worm to travel lengthwise in exactly the same way as the teeth of the imaginary rack when rolled with the gear. The worm then will serve as well as the rack for molding the teeth of the gear. In practice, the worm is gashed or fluted, and relieved; in other words, it is a hob. It is rotated in the required ratio with the work, and fed gradually through it from one side of the face to the other. When it has passed through once, the work is completed.

Description of Experiments

For carrying out the experiments, three sets of blanks were provided, each for a gear of 6 pitch, 21 teeth. They were arranged as shown in Fig. 2, with two wide-faced outside blanks

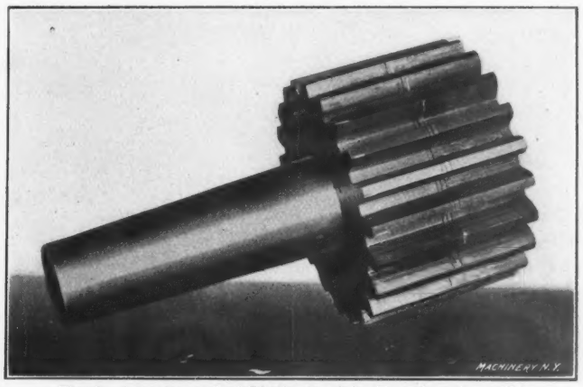


Fig. 2. Arrangement of Blanks used for Experiments on the Hobbing Machine

enclosing a pair of thin templets. The thick outside blanks allow the cutter to get right down to business before starting in on the templets; at the same time they are stiff enough to firmly support the templets, and were accurately faced so that the teeth of the templets showed practically no burrs whatever, leaving the sharp, clear outline of the cut. After each blank was cut, the templets were removed, one was reversed and matched up on the other, so as to compare the tooth outlines. By matching them up in this way in their reversed position, it was very easy to see whether or not the teeth were exactly the same shape on both sides. The prevention of "hooked" teeth is reported to be one of the difficult problems in gear hobbing.

To identify the blanks after being cut in the hobbing machine, each set was numbered, as shown in Fig. 3. The topmost blank was lettered *A*, the upper templet *B*, the lower

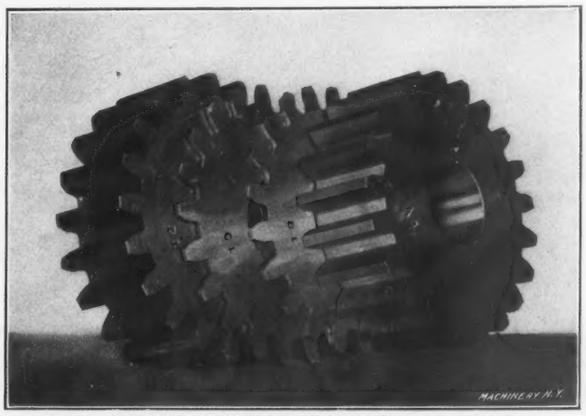


Fig. 3. The Blank separated into its Four Component Members, showing the System of Identification Employed

templet *C*, and the bottom blank *D*. The first set of blanks was numbered A_1, B_1, C_1, D_1, and the second set A_2, B_2, C_2, D_2, etc.

There are three theories propounded as to the cause of hooked teeth. One of these is that the difficulty is caused by not exactly centering one tooth or tooth space of the hob with the work. Manufacturers of hobbing machines provide indicators for making this setting very accurately. Another theory claims that hooked teeth are the result of the long and complicated mechanism, by means of which the movements

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of the hob and blank are connected. The various shafts, bearings, gears, etc., in this connection, all give chance for play and elasticity, and this elasticity produces torsional vibration between the hob and the work, resulting in an irregular movement of the former in relation to the latter. This, it is asserted, produces unsymmetrical teeth. The third theory lays the difficulty to the inaccuracies in the hob, due to hardening.

The three blanks were cut as follows:

1st blank:—Roughing and finishing cut. Finishing cut at fine feed. A tooth of the hob accurately centered. Blank made of brass.

2d blank:—Roughing and finishing cut. Finishing cut at fine feed. Hob tooth not centered. Blank made of brass.

3d blank:—Heavy feed taken at one cut. Tooth of hob centered. Blank made of steel.

By taking a very fine finishing feed in a soft material, we have reduced any possible trouble from torsional vibration to a minimum, with Blanks 1 and 2. As one blank is cut with a hob tooth centered, and the other with no tooth on center, a comparison of these two blanks should show the effect of the centering of the hob tooth.

Blanks 1 and 3 both have the same tooth of the hob set centrally, but one is made with a fine finishing cut in soft material, while the other is made with a single heavy cut in hard material. A comparison of these two blanks should therefore show what effect torsional vibration has on the question of cutting symmetrical, accurate teeth.

If neither the centering of the tooth nor the torsional vibration of the hob were shown by these previous experiments to have any particular effect on the shape of the teeth, it would be time to look for trouble in the hob itself.

Centering the Hob Tooth

The effect of centering a tooth of the hob, on the matter of the symmetrical shape of the tooth, is one that demands a little explanation. There is but one plausible explanation of any effect that this may have so far as the writer can discover.

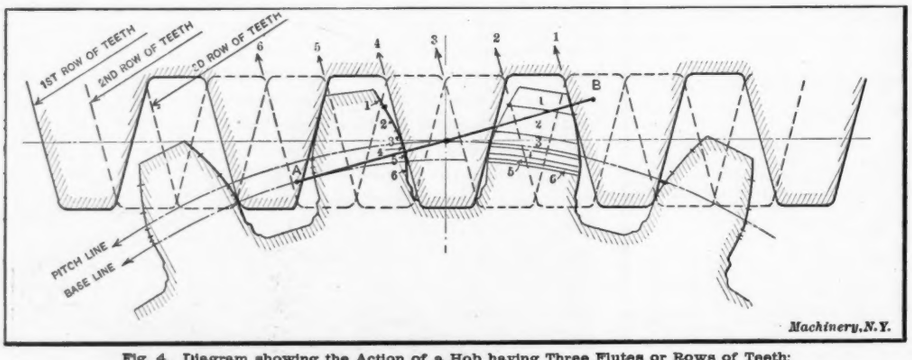

Fig. 4. Diagram showing the Action of a Hob having Three Flutes or Rows of Teeth; Flats are produced on the Teeth as shown

This explanation, as shown in Fig. 4, depends on the fact that a hob does not generate in the gear a theoretically perfect involute curve, but appoximates it by means of a series of flats.

In Fig. 4 we have a hob which, to make the action clear, is provided with three rows of teeth only. Each row of teeth, as it comes around into action, occupies the successive positions shown by the full and dotted outlines. These three successive positions each form a portion of the tooth outline, and each leaves a straight side, as indicated. This succession of straight sides approximates the curve of the involute.

If there were more rows of teeth in the hob, there would evidently be a greater number of flats, and the involute would be more closely approximated. If, instead of having teeth, the hob were a worm, ungashed, and made of emery or some other abrasive so as to be able to cut the work, there would be no flats whatever, theoretically, since the worm would cut over its entire surface. The more teeth, the finer the flats and the nearer to the true involute the work is produced.

It is interesting to note that these flats have been discovered recently by Mr. George D. Grant. He wrote an article about them in the *American Machinist* for June 23, 1910. Probably every gear man has known about them from the beginning. An English hobbing machine maker, Mr. Humpage, mentioned them in a paper read over two years ago; and these flats are identical with those long known to be produced in the hobbing of worm-wheels. This matter was discussed in connection with worm-wheels in an article by the writer, entitled "How Many Gashes should a Hob have?" in the January, 1909, number of MACHINERY. The same difficulties there mentioned as met with in the use of multiple-threaded hobs, apply to multiple-threaded spur-gear hobs also.

Now when a tooth of the hob is centered, as shown in Fig. 4, the flats on each side of the tooth are symmetrical, leaving a symmetrical tooth. If a tooth space is centered instead of a tooth, the flats are still symmetrical, though arranged somewhat differently, as also shown at the left of Fig. 5. It is thus as satisfactory to center a tooth space as a tooth. If, however, neither a tooth nor a tooth space is centered, the flats, as may be seen at the right of Fig. 5, are unsymmetrically arranged, and the tooth is unsymmetrical.

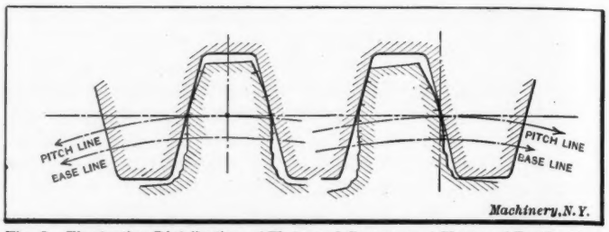

Fig. 5. Illustrating Distribution of Flats and Consequent Shape of Teeth—First with Tooth Space Centered, Second with Both Tooth and Space Off Center

The Importance of the "Flats"

Fig. 4 shows quite plainly how the number of flats on a hobbed gear tooth may be estimated. There will be as many flats on each tooth as there are separate positions of the cutting edge of the hob in the length of the line of action, *A-B*. In the case shown this line of action is limited at *B* by the outside diameter of the gear, and at *A* by the base line. In the length *A-B* there are six positions of the cutting edge, marked "1," "2," "3," "4," etc., which form the six flats correspondingly numbered.

The particular hob used in the experiments had sixteen flutes. These figures ought to give about twenty-eight flats in the length of each tooth. It will be seen, therefore, that it is extremely unlikely that any change in the distribution of flats as small as those could be detected at all. And it is therefore unlikely that the centering of the hob is of any use at all—at least so far as this matter is concerned. But more of this later.

Another point of interest in this connection is shown in Figs. 6 and 7. In the first case are shown the four successive positions taken by the teeth of a four-fluted hob. There are, it will be seen, four separate central positions for the hob teeth, in a distance equal to the circular pitch. These positions are numbered "1," "2," "3" and "4." In Fig. 7 is shown a similar diagram for a three-fluted hob, like that in Figs. 4 and 5. Here there are shown to be three positions in which a hob tooth is centered, and three other intermediate positions in which a tooth space is centered. The tooth spaces do not line up with the teeth as in the even-fluted hob. In a length equal to the circular pitch, there are, then, a number of central positions equal to the number of flutes for the even-fluted hob, and a number of positions equal to twice the number of flutes for the odd-fluted hob.

Since the number of flutes in the hob used in the experiments was even—sixteen—the distance to move it from a central position to a position half way between two central positions, or out of center, is found by dividing the circular pitch by twice the number of flutes. In this case we had:

$0.5236 \div (2 \times 16) = 0.016 + =$ amount of shift necessary.

University of Iowa 7 JAN 1911

Results of the Experiments

The blanks were cut as described. Then came the question of the various methods of comparing them. The simplest was the visual method of comparing the templets. The templets of the first blank, when reversed and matched together again in the manner previously described, showed a noticeable lack of symmetry. The teeth had a marked flat on one side at a point where they were well rounded on the other. There was also a slight shoulder at the base of the involute on each side, as might be expected, but this shoulder was considerably lower on one side than on the other. The templets of Blank 2 showed the same phenomenon, but to a considerably less degree. The teeth of the templets in Blank 3 were almost entirely symmetrical.

Another test that would naturally be applied by a gear man would be the rolling of the blanks together, either in the hands or on fixed centers set the proper distance apart. In either case the two outer wide-faced gears in Blank 1 rolled together very roughly, when both were the same side up as when they were cut. When one of them was reversed, they practically interlocked, so that movement was nearly impossible. This is what would be expected from unsymmetrical teeth. In fact, a good rough-and-ready test for symmetry can be made by rolling gears together before and after reversing one of them. If there is any difference in the action in the two cases, the teeth are unsymmetrical.

In Blank 2 the action was considerably better. The gears did not run so well when reversed, but they did not interlock. With Blank 3 the action was reasonably good, with comparatively little difference when the gears were reversed, although in no case was the action what would be expected of a high-grade gear.

A third test was applied with a special apparatus on the principle shown in Fig. 8. The gears were mounted so as to

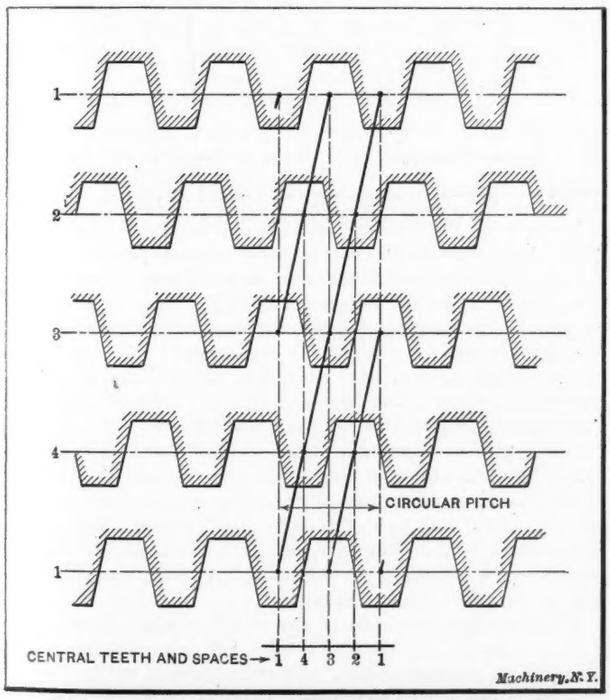

Fig. 6. Number and Location of Central Positions for Hob having an Even Number of Flutes

run, one on arbor *F*, and the other on a pivot on swinging arm *K*, being pressed into contact meanwhile by a not too heavy spring *N*. The dial indicator *M* reading to thousandths, was so mounted as to show the up-and-down movement of gear *H*, produced by irregularities in the tooth curves, as the gears were rotated. The results of this test with gears running the same side up and reversed, for all three blanks, are shown in the accompanying table, together with notations as to the smoothness of running of the gears as felt by the hand in rotating them.

Now the question is—what do these experiments show? The table will do very well as a basis of comparison, as it agrees with the results of the two previous tests.

By comparing Blanks 1 and 2, it will be evident that centering the cutter did not improve the shape of the tooth produced; in fact, for some reason, it appeared to aggravate the error. So far as these experiments are concerned, then, the centering of the tooth appears to have little effect on the results. It should be noted that the hob had 16 teeth, a number sufficient to give so close an approach to the theoretical involute that the centering of the tooth should have little or no effect. Secondly, by comparing Blanks 1 and 3, it would ap-

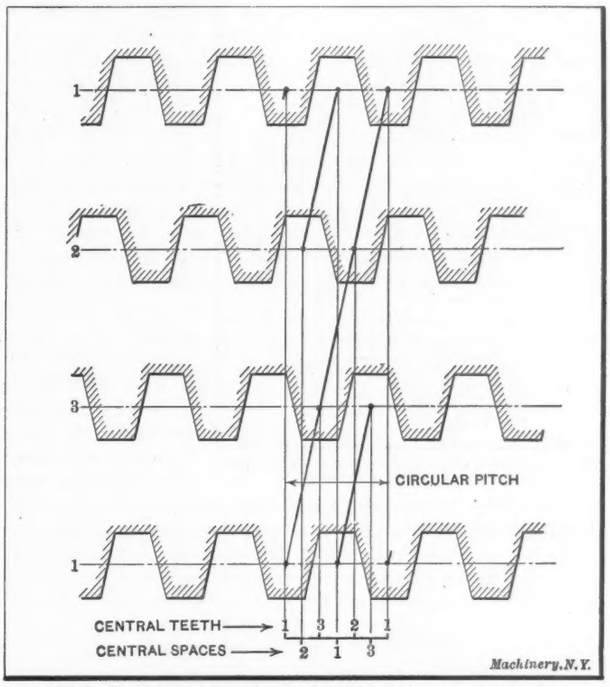

Fig. 7. Number and Location of Central Positions for Hob having an Odd Number of Flutes

pear that the torsional vibration of the machine has a mysterious effect. It would appear, in fact, that the more severe the strain on the driving mechanism, the better the gear. How is this?

Backlash and Spring in the Hobbing Machine

In explanation of this peculiar result, it should be stated that the particular hobbing machine used was so adjusted as to run freely in all its slides and bearings. It ran, in fact, rather more freely than it should have, in the judgment of the writer. He did not, however, go over the machine, tighten up the spindle and worm bearings, the gibs and other parts—first, for the reason that there was plenty of work for the machine, so that he did not feel justified in trespassing too long on the hospitality of the shop manager; and secondly, he did not at that time fully realize the importance of close adjustment in a gear-cutting machine.

The importance of this matter of adjustment he learned later by cutting two sets of similar gears on the Fellows gear shaper, one with the machine adjusted to the normal freedom of movement with which it is supposed to be used, and the other with adjustments loosened somewhat, particularly with the worms loosened in the worm-wheels which rotate the cutter and work spindles. A gear cut with a loose adjustment gave almost as poor results as the best of the hobbed gears, when tried in the apparatus shown in Fig. 8. A gear cut with the normal close adjustment, however, was far superior.

One conclusion, then, which can be drawn from these three experiments, is this—that the superiority of the shape of tooth in Blank 3 is caused by the fact that the machine was cutting under continuous strain, which took up all looseness, play and backlash in the driving mechanism, resulting in a generating action superior to that in the two preceding cases.

In this matter of looseness and play in the mechanism, the gear-hobbing machine is at a serious disadvantage. For one

thing, the rotating connection between the hob and the work must necessarily be long and complicated, owing to the adjustments of the machine. The spindle is mounted on a head which is adjustable to various angles, and is itself mounted on a slide which has a horizontal or vertical movement for the feed. This construction requires a complicated combination of bevel or spiral gears, spur gears, etc., of small diameter, with shafts having restricted bearings. At the same time, it requires a large overhang of the hob spindle beyond the face of the column.

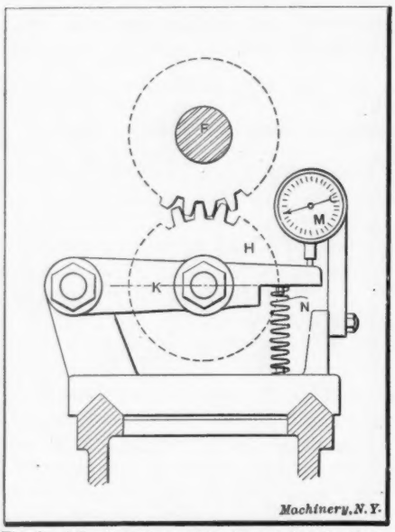

Fig. 8. A Testing Rig used for Comparing the Gears cut in the Hobbing Experiments

In the case of a hobbing machine arranged for cutting spiral gears, the chance for looseness and play is usually aggravated by passing the motion through a differential gearing, which gives a chance for looseness in itself, besides adding to the sum total of the looseness all that of the feed mechanism. The fact that we can obtain better spiral gears than spur gears from a hobbing machine is simply due to the inherent smoothness of action of the spiral gear, which tends to disguise poorness in design or workmanship by the smooth manner in which the teeth come into and out of action.

Hardening Troubles in the Hob

There comes next the question of why a gear cut with the teeth off center should be more accurate than one with the teeth accurately centered. The only suggestion that occurs in this connection is one offered by a firm which has experimented largely with the question of hobbing. They have found, for instance, that by setting one tooth of a hob central, the teeth will be hooked in one direction; by centering the next tooth to it, the teeth may be symmetrical, while by centering the next tooth, all the teeth may be hooked in the other direction. It is their custom, in fact, to test each new hob in actual gear cutting, centering one tooth and then another until a tooth is found which, when centered, will give symmetrical gears. This tooth is then marked, and the hob is always centered on that tooth.

COMPARISON OF GEARS BY TEST SHOWN IN FIG. 8.

Sample No.	One Gear Reversed		Both Gears Same Side up	
	R. H. Rotation	L. H. Rotation	R. H. Rotation	L. H. Rotation
1	0.015 Interlocked	0.015 Interlocked	0.004 Hitchy	0.004 Smooth
2	0.015 Hitchy	0.015 Hitchy	0.004 Hitchy	0.003 Smooth
3	0.012 Fair	0.010 Smooth	0.006 Hitchy	0.005 Smooth

The only possible explanation of action as eccentric as this is that the teeth of the hob in hardening are distorted, some of them one way and some another. By shifting the hob endwise, so that one tooth after another is centered, a position can be found in which these various inaccuracies tend to neutralize each other, and a more or less symmetrical tooth is produced. In all probability, then, in the case of Blank 1, the particular tooth centered was the one which should not have been centered. Perhaps if some other tooth had been tried, a more satisfactory result would have been obtained.

This question of keeping the hob in shape during the hardening process is one of the most serious the hobbing machine has to contend with. The difficulties met with in hardening the ordinary formed and relieved cutter are immensely magnified. One experimenter, who has gone extensively into this matter, claims that he has solved every problem except this one. Until some method for retaining the shape of the hob in the heat treatment process is devised, or until some scheme for grinding the hob after hardening is discovered, this man was content to ignore the hobbing process for good work. In this connection it may be noted that a hob ground after hardening has recently been advertised, but no particulars of its construction have been made public as yet.

A number of American firms have claimed to be able to buy much better hobs abroad than they can obtain at home. If the foreign hob is really superior, it may be due to some improved method of hardening which we have not yet found out; but its superiority may be due to another reason. In a batch of ten hobs, it is very likely that two or three would come out of the fire in very decent shape, not warped enough to do much harm. Is it possible that these two or three hobs would be sent to this country, while the poorer ones would be retained on the other side, where (as the writer has been given to understand) the hobbing machine is now generally used for roughing only? This, however, is mere surmise.

Details of Hob Design

Now there are other difficulties to be contended with in the hob itself, outside of those previously mentioned in connection with keeping the shape through the hardening process. If the hob is to cut standard 14½-degree gears, it must be so shaped that it will make the required corrections for "interference" on the flanks of the small pinions and on the points of all the gears from the smallest to the largest. The particular hob used appeared to have absolutely straight sides, without correction of any kind. As a result, the product showed a considerable undercut in the flank, reducing the length of the involute bearing surface a trifle. If this hob had been cutting a 12-tooth pinion, the flank would have been so undercut as to take away about half the bearing between the base line and the pitch line; in the 21-tooth gear, however, it does not undercut so badly. The hob should be corrected for this interference by relieving the points of the teeth, and filling in the flanks to the proper shape.

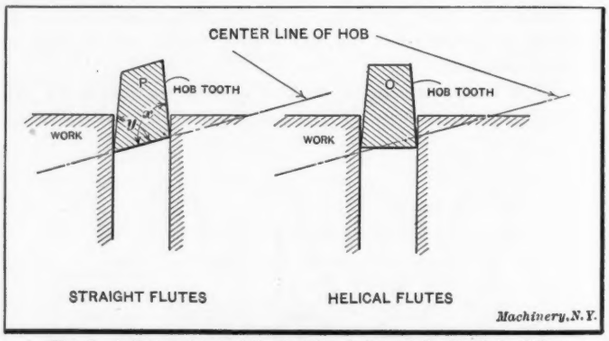

Fig. 9. A Comparison of the Cutting Action of the Teeth in Hobs cut with Straight and with Helical Flutes

Another slight criticism of the hob that might be made is that the corners of the teeth were left quite sharp. There seems to be no good reason why these corners should not be rounded down pretty nearly to the extent of the extra length of tooth added for clearance. This would serve two purposes. The corner of the tooth is the first part to suffer under heavy duty, and it will stand up much longer if it is rounded than if it comes to a sharp point. Besides this, the fillet at the base of the tooth of the gear, and the relieved portion of the flank, are generated by the point of the cutter, and a rounded point gives a smoother surface than is given by a sharp corner.

There is some question as to whether hobs should be made with straight or helical flutes. The helical flute has the disadvantage of requiring a special and rather complicated mechanism for grinding, as it has to be very accurately guided

with exactly the same twist it had when the flutes were milled and the teeth relieved. Except for this, however, the advantage is all with the helical fluted hob. Where the flute goes straight across, as shown at *P* in Fig. 9, one side of the tooth is left with an obtuse cutting angle *x*, while the other has an acute angle *y*. This results in crowding the hob lengthwise, and in a difference in finish on the two sides of the teeth. The helically fluted tooth *O* avoids this trouble.

So far as the matter of the theoretical action of a straight- or helically-fluted hob is concerned, there is no difference, provided only that the tool, which forms and relieves the teeth, is properly set. For a straight-fluted hob, it should be designed to be used with its face in the same plane with the axis of the hob. For a helical-fluted hob, it should be designed to be set at the helix angle. The face of the relieving tool must match up with the face of the hob tooth it is cutting. If this precaution is observed, it makes no difference so far as the theoretical action is concerned, which way the hob is made.

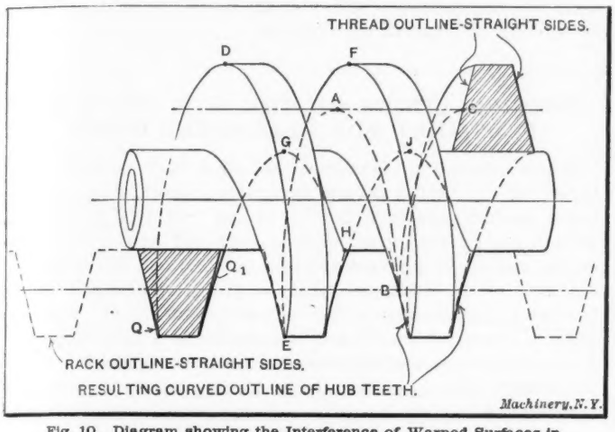

Fig. 10. Diagram showing the Interference of Warped Surfaces in Relation to the Shape of Hobbed Teeth

The Interference of Warped Surfaces

There is another theoretical consideration in the design of the hob, which is worthy of mention. The actual effect on the gear is small in comparison with the other factors we have been describing. For a standard of workmanship as high as that met with in the best gear-generating processes, however, it should be considered. This point relates to the nature of the contact between warped surfaces. To illustrate: Suppose a worm, such as shown in Fig. 10, is set into a rack, as shown, at the proper helix angle as measured at the pitch line. If the worm were cut with a straight-sided tool of the same shape as the rack, it would be the natural impulse to say that it would fit exactly in the rack, making contact on the perpendicular plane passing through the center line of the worm. This is not the case, however, as is best seen at the lower dotted section, where the worm has been cut down to this central plane.

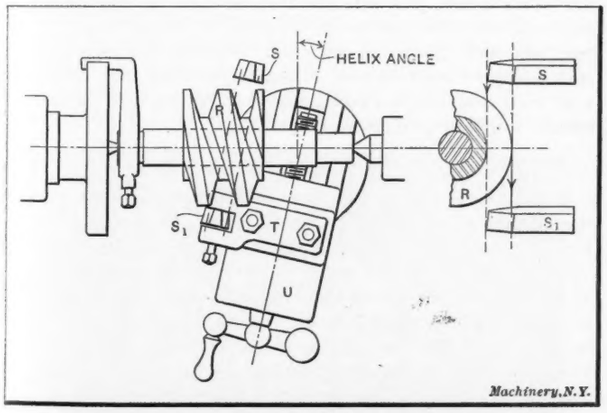

Fig. 11. Turning a Master Worm in which the Interference of Warped Surfaces is corrected

At *Q* and Q_1 we see that parts of the worm tooth beyond the central section project outside of the rack outline, at both the top and the bottom of the tooth. The reason for this should be evident. The worm is set at a helix angle calculated from the pitch diameter. This helix angle is right for the pitch diameter, but is too great for the outside diameter and too small for the bottom diameter of the worm. Consequently, in the lower view, the pitch-line *A-B-C* comes to a sharp point at *B*, as it should; the outside line of the tooth loops, as shown at *E;* while the bottom line of the tooth curves in the opposite direction, as shown at *H*.

What is true of a worm, is true of a hob made from that worm. If made with a straight-sided tool, the hob will cut teeth which are of the proper thickness at the pitch line, but are thinned slightly at the point and at the root. In Fig. 11, of course, the error has been exaggerated by showing a worm of very coarse pitch in relation to its diameter. In any worm or hob met with in practice the error would be much less. But if the hob is to do work as accurate as that performed by other generating machines, such as the Bilgram and Gleason bevel-gear machines and the Fellows gear shaper, for instance, this would have to be remedied. A suggested remedy is shown in Figs. 11 and 12.

First rough out a tool-steel worm, of the dimensions desired for the hob. This worm is to be finished as shown in Fig. 11. At *S* is a tool of the exact shape of a rack tooth of the pitch desired. This is mounted in the special holder *T*, attached to the compound rest *U*, which is set to the required helix angle. The tool passes under the work *R*, and is fed from back to front along the dotted lines shown, being set at the proper height to finish the work to the proper diameter. Worm *R* is now of exactly the right shape to make accurate contact with the rack, instead of interfering as shown in Fig. 10.

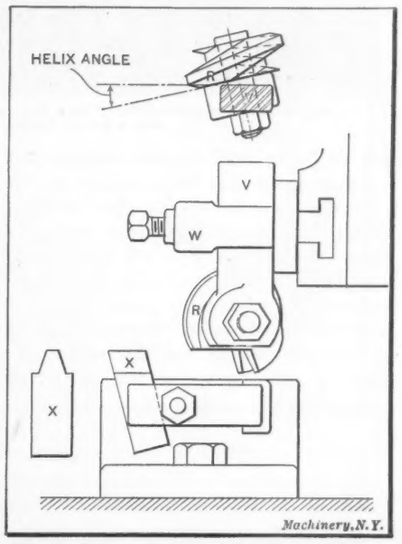

Fig. 12. Using a Section of the Master Worm of Fig. 11 as a Tool for Shaping the Forming and Relieving Tool used in making a Corrected Hob

In Fig. 12 a section of the same worm is shown at *R*. Here it is being used as a circular master tool for shaping the tool *X*, which is to perform the actual work of forming and relieving the hob. For this reason the worm of Fig. 11 has been gashed, hardened, sharpened and mounted in the holder *V* in the shaper toolpost *W*. This holder locates it at the same helix angle as that to which the rest was set in Fig. 11. The cutting edge of the circular form tool *R* is set to the same angle as that desired for the rake of the relieving tool *X*. The latter is held on a knee, clamped to the shaper table, as may be seen.

This somewhat roundabout procedure would give a relieving tool *X* which would produce a hob with interference errors eliminated. If the hob were made on the "stub-tooth" or other similar system, in which no correction of the involute has to be made, the resulting hob from a straight sided tool *S* should be of exactly the desired shape—before hardening, at least.

Feed and Finish

Besides the various other factors which were foreseen in the experiments we have described, there was one of great interest which was new to the writer. Its nature is shown in Fig. 13, which illustrates a section of steel blank No. 3 of the experiments, which was cut with a heavy feed. To be exact, the feed was ⅛ inch per revolution of the work. The hob was single-thread, and revolved at 43 revolutions per minute. This, with a 21-tooth gear, gives about 5¼ inches per minute, reduced to the usual basis of comparison with the

orthodox milling type of automatic gear-cutter. This is "going some" for 6 pitch in steel, it must be admitted. The machine stood it without the slightest difficulty, but the hob was dulled by one passage through the blank.

The point to be noted is the finish. There is a shallow, spiral groove, ⅛ inch wide, around and around the gear from top to bottom. This shows on the sides of the teeth as well as on the bottom, and would be thoroughly objectionable in a finished gear, as compared with work produced at a similarly lively pace in the milling type of machine or on the gear-shaper. The question is, can the high output claimed for the hobbing machine be attained without sacrificing finish? And when a good commercial finish is obtained, will not the out-

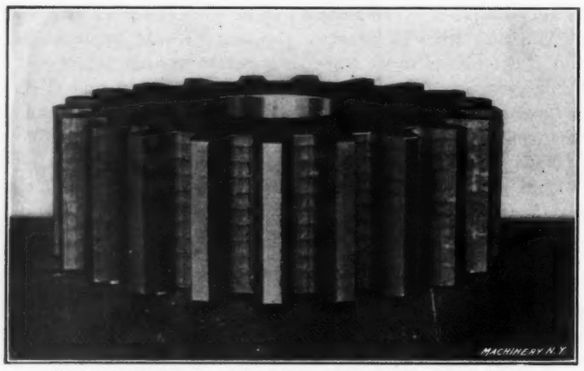

Fig. 13. Feed Marks produced on a Gear which was hobbed with a Heavy Feed

put be below that of other commercial methods? It will be interesting to hear from others on this point.

In Fig. 14 is shown the effect which a variation in diameter of the hob has on these feed marks. With hob teeth of the same size, so that there are twice as many in a hob of twice the diameter, the large hob will feed twice as far per revolution when taking the same chip per tooth. As it will take only half the number of revolutions per minute to keep the same surface speed, the rate of output will remain the same. Feeding twice as far, with a hob of twice the diameter, will

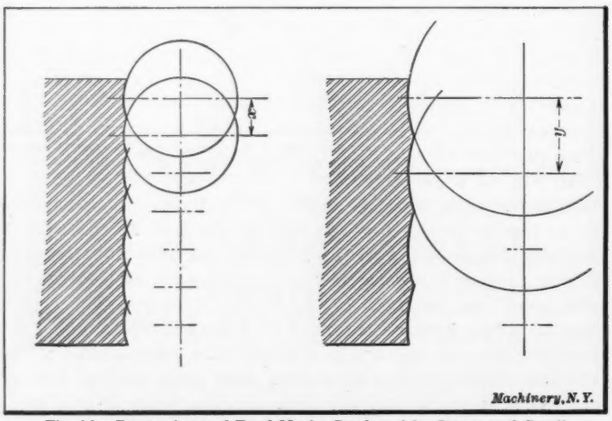

Fig. 14. Comparison of Feed Marks Produced by Large and Small Hobs at the Same Thickness of Chip per Tooth

give feed marks twice as wide and deep, as shown. The difficulty is thus magnified in the case of inserted tooth hobs, which must of necessity be larger in diameter than the ordinary solid ones.

Summary

The writer, then, comes to the following conclusions in regard to the hobbing process:

There is no advantage in centering a tooth of the hob, except to center any one particular tooth which may chance to equalize the errors of hardening.

There is a great advantage in reducing backlash and spring throughout the whole machine.

In the latter connection, the machine is handicapped in its fundamental design, and a premium is put on unusual inventive skill in getting around the long, limber drives, and the numerous joints and overhangs required.

The hob is a very difficult hardening proposition; and inserted tooth hobs, which might be ground after hardening, would be so large as to give coarse feed marks, as well as increase the difficulties of overhang and weakness in the drive.

The hob, for really good work, should be corrected for interference of the kind shown in Fig. 10. For 14½-degree standard gears, it should also be corrected for interference with the flanks of the teeth of small gears.

The hob should be spiral fluted, and have the corners of the teeth rounded.

When all the other practical and theoretical difficulties of the hob and machine have been remedied, there may still remain the unsatisfactory nature of the finish, in any case where an attempt is made at high output.

* * *

SPECIFICATIONS OF THE U. S. NAVY DEPARTMENT FOR HIGH-SPEED STEEL

Specifications for high-speed tool steel have recently been issued by the United States Navy department. According to these specifications each bar up to and including a sectional area of 2¼ square inches shall be delivered with a test piece on one end equal in length to about one and one-half times the diameter. This test piece should be nicked on each side while the bar is hot, so that it may be easily broken off. The test piece is preheated slowly and thoroughly in a preheating furnace to a uniform temperature of about 1550 degrees F. When thoroughly heated, it is quickly transferred to a high-heat furnace and rapidly heated to a temperature just below the melting point, when it is quickly removed from the furnace and cooled in a heavy air blast. Each test piece is then ground off on one end with a wet emery grinder an amount equal to one-half the thickness of the test piece, leaving the end after grinding of a V shape. This V-end must test "file hard." Each bar failing in this test is rejected, and another bar furnished in its stead by the makers. If 10 per cent of the bars of any lot fail to meet the test, the whole lot may be rejected.

From each lot of tool steel one or more tools are forged and heat-treated. The tools are ground to a uniform standard shape for lathe tools, and are then given a 20-minute test on a steel forging of open-hearth steel, either nickel or carbon, which has been annealed. The minimum tensile strength of the forging on which the tool is used is to be 80,000 pounds per square inch, the minimum elastic limit 50,000 pounds per square inch, the minimum elongation in two inches 25 per cent, and the maximum contents of phosphorus 0.06 per cent, and of sulphur 0.04 per cent. A lathe tool known as ⅞-inch standard must be able to take a cut 3/16 inch deep with 1/16 inch feed and a surface speed of 60 feet per minute for twenty minutes without regrinding.

* * *

A simple method of arriving at a commercial estimate of the relative values of different tool steels, is described by the *Zeitschrift des Oesterreichischen Ingenieur und Architekten-Vereins*. The tools are tested by cutting or turning a disk of steel 20 inches in diameter and 2 inches thick, which is held in a lathe. At the center the disk has a hole 4 inches in diameter. The various tools to be tested are used one after the other on the disk, the disk being revolved at a suitable cutting speed. The cutting is started at the center and continued until each tool becomes blunt, each tool, of course, taking a cut of specified depth. The better the steel the greater will be the diameter at which the tool fails. To obtain a commercial estimate of the value of various grades and qualities of tool steel, the prices per pound of the steels are divided by the diameter at which they failed. The quotients thus obtained may be taken as indicators of the value of the steel, the smallest figure, indicating the relatively cheapest steel. In one test undertaken with the seven steels it was found that the relatively best results were obtained with the steel next cheapest in price per pound, while the most expensive steel which, in fact, was nearly 30 per cent higher in price, was relatively about 25 per cent less efficient.

PNEUMATIC PRESS FOR REMOVING SPRING BANDS

By S. WHEAL*

The accompanying illustrations show a pneumatic machine for removing spring bands, recently designed and built in the Wabash shops at Springfield, Ill. Since its installation it has proved to be a valuable asset, not only in the amount of work it can do, but also in the saving of labor as compared with the old, cumbersome method of removing the bands.

Reference to Fig. 1 will give an idea of its construction.

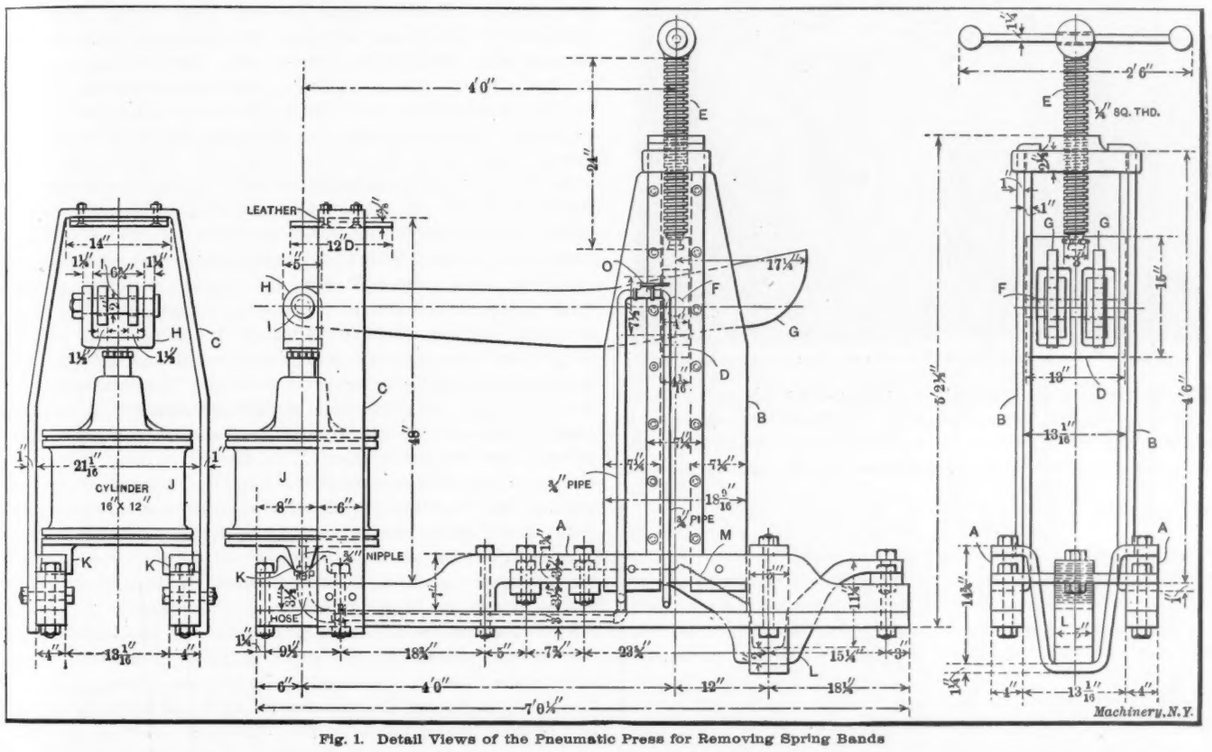

Fig. 1. Detail Views of the Pneumatic Press for Removing Spring Bands

The frame of the machine consists of two parts *A* to which are bolted guides *B* near the front end of the machine, and a frame *C* at the rear end. These base frames *A*, are composed of old front engine frames, with two discarded side rods bolted below; but where desired these frames might just as readily be made from channel iron. Each of the guides *B* is composed of three pieces riveted together as shown, in such a manner as to form guides for the crosshead *D*, which moves vertically in these crosshead ways and is controlled in its movement by a coarse-pitch square-thread screw *E*, passing down through the top connecting piece.

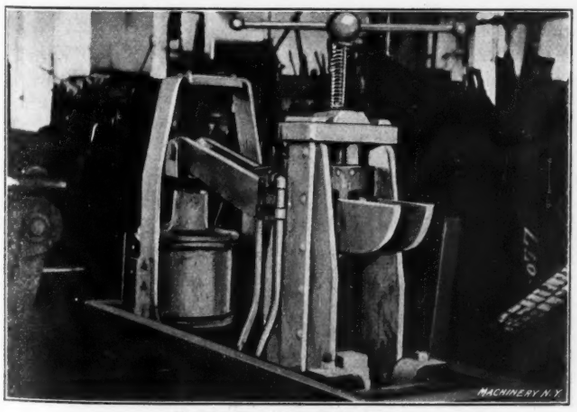

Fig. 2. The Pneumatic Press

In the crosshead *D* there is a wrist-pin *F* on which are two levers *G* which pass to the back of the machine and are attached to a rear crosshead *H* through another wrist-pin *I*. This crosshead is integral with the piston-rod of a 16 by 18 inch air cylinder *J*, supported in V-shaped grooves *K* in which it may oscillate. Beneath the vertical guides *B* and attached to the frames *A* by cross pieces, is a pocket *L* made from an old steel axle. The back of this pocket has gripping teeth, as shown at *M*, the use of which will be explained later.

The manner of operation is as follows: The spring which is to have its band removed is placed in the pocket *L*, as shown in Fig. 5, with a supporting grip-block *N* resting on the previously-mentioned tooth-face *M*. This grip-block *N* is so adjusted that the rounded faces of levers *G* just come over the center of the spring band. Adjustment of the screw *E* brings levers *G* on top of the spring band and then by manipulating the air valve *O* air pressure in the cylinder *J* raises the rear end of the levers *G*, (pin *F* acting as a fulcrum) forcing down the spring band. Releasing the air valve and bringing *H* back to its original position and again screwing the levers *G* down on the new position of the spring band by means of the screw *E*, the operation may be repeated until the spring band is completely removed.

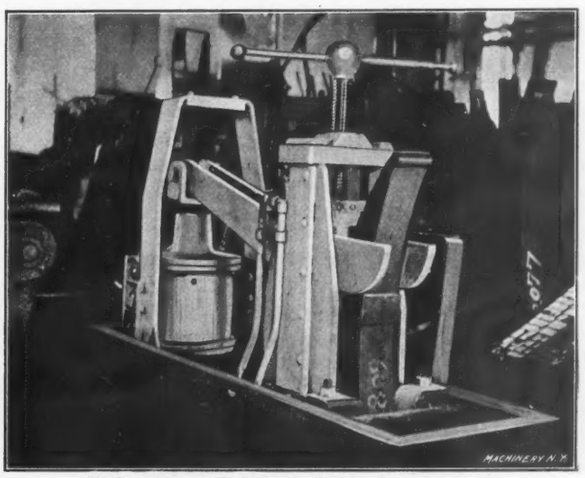

Fig. 3. Press with Spring in Position to be removed

The action of the grip-block *N* is quite apparent, for otherwise, when pressure is brought to bear on the levers *G*, the spring would tend to bend, but the grip-block *N* holds it rigidly in position. Different sizes of grip blocks are provided

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for the various types of springs to be operated upon. Figs. 3, 4 and 5 are photographs of this mechanism showing its general appearance, ready for use, and finally with the spring band removed. It will be noticed in Fig. 5 how far down the screw *E* has been depressed.

With regard to the expeditious manner in which spring bands may be handled, it might be mentioned that for pressing off the band of an eight-leaf tank spring the average time required is one minute; for a twenty-leaf driving spring, two

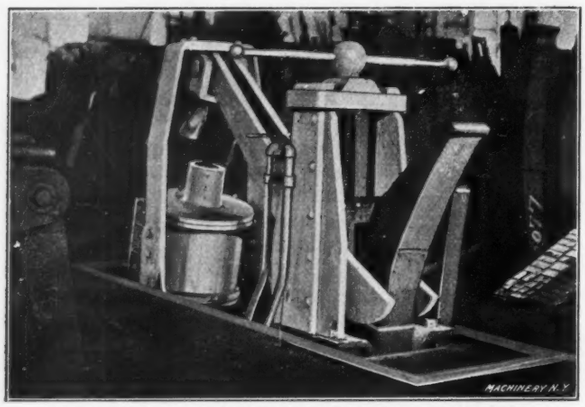

Fig 4. Press at Completion of the Spring Removal Operation

minutes; and for an engine truck spring, two minutes. These figures merely give the actual operating time after the spring has been placed in position in the machine. For the complete operation, the capacity of the machine may be judged from the

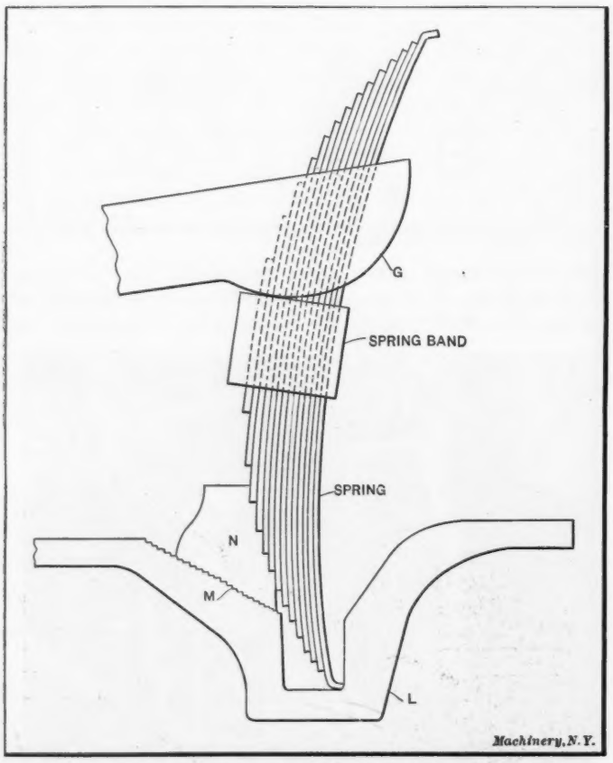

Fig. 5. Heavy Spring in Position to have Band removed, showing the Use of the Grip Block

fact that it only required twenty-three minutes for one helper to remove the bands from twelve eight-leaf tank truck springs.

* * *

An electric railway system is being installed at the "Hill Shops" of the United States Armory at Springfield, Mass. This will be connected with the local street railway and through that with the steam railroad, thus improving the facilities for handling materials to and from the transportation companies as well as between the "Hill" and "Water Shops."

THE AIR BRAKE AS RELATED TO PROGRESS IN LOCOMOTION

A lecture was delivered before the Franklin Institute of Philadelphia on the evening of November 17, by Mr. Walter V. Turner, chief engineer of the Westinghouse Air Brake Co. of Pittsburg, Pa., on the general subject of "Air Brakes."

The paper, in connection with the stereopticon views which accompanied it, embraced the development of the art of braking from the earliest and most primitive forms of brakes for road vehicles through the early stages of the art as related to the primitive forms of railway wagons used on the first steam railroads, down through the various stages of progress in steam railroading, to the most improved types of apparatus as used at the present time. The discussion of the various forms of brake apparatus developed from time to time was accompanied in each case by an exposition of the service conditions which required the development of more efficient types of brakes.

Past and present conditions under which railroads are forced to handle the traffic of this country were contrasted in order to illustrate the fact that facilities for controlling railroad trains have not advanced relatively to the requirements, and that, as a matter of fact, the brake has not kept pace with the developments in locomotion. That is to say, even the most efficient brake of today is, at its best, not able to control and stop a train in as short a distance as when the weight and length of the train was less than one-fourth of what it now is. That the stopping distances of modern heavy high-speed trains are not longer than they are, is a source of gratification when it is considered that the length of the train and the volume of air to be handled in controlling the train have rendered the problem vastly more difficult so far as service control is concerned, and the increase in weight and speeds are such as would require at least twice the distance in which to stop modern high-speed passenger trains, if the old type of brake had to be used.

It is difficult for one who has not given the subject careful thought to realize the great changes in railroad equipment and operative requirements which have taken place since the introduction of the air brake. For example, in one of the earliest brake trials in the history of continuous brake, made on the Midland Railroad near Newark, England, in 1875, a stop was made from 53 miles per hour (the highest that could be obtained) in 18 seconds. This corresponds to 15.5 foot-tons of work per brake shoe per second. To stop a modern train of heavy Pullman cars from a speed of, say, 75 miles per hour (which can be obtained under favorable conditions) in the same time, namely, 18 seconds, would require about 4½ times as much work per brake shoe per second as in the case of the Midland Railway train. The tremendous significance of this increase in power demanded is but one aspect of the question and is mentioned simply to indicate the nature of the problem which must be solved.

As the capacity of a chain cannot exceed the strength of its weakest link, so the progress of transportation depends absolutely upon our ability to control the medium of interchange.

After a brief historical review of early forms of brakes, the paper discussed, in order, the steam brake of 1833, patented by Stephenson for use on his original steam locomotive, and the growth of the idea of continuous brakes which became prominent as more cars were drawn in trains. This led to the invention of the first form of air brake—the straight air brake—by Mr. George Westinghouse, in 1869. The early trials of this brake soon demonstrated the adaptability and efficiency of compressed air as a medium for transmitting and controlling the force to be used for retarding or stopping the motion of railroad vehicles through the medium of blocks or shoes rubbing on the periphery of the wheels.

The necessity for greater protective features as well as for meeting more severe traffic demands, led to the substitution of the plain automatic brake for the straight air brake, and with the introduction of the automatic feature the brake equipment may be said to have entered upon the course which it has followed consistently up to the present.

With the advent of longer trains, especially in freight service, and as a result of the important and well-known tests made by the Master Car Builders' Association on the Chicago, Burlington & Quincy R. R. in 1886 and 1887, the quick-action feature was added to the plain automatic brake for the purpose of hastening the application of the brakes throughout the train in case of an emergency application being made. The introduction of this quick-action feature solved for the time being the problem of obtaining a practicable and effective pneumatic brake by means of which trains of maximum length (fifty cars in those days) could be handled without damage to equipment or lading. This achievement was noteworthy from the fact that the official report of the Master Car Builders' committee in charge of the brake tests referred to, expressed serious doubt as to the possibility of accomplishing the desired and necessary results without the aid of electrically controlled pneumatic brakes.

The necessity for maintaining safe and efficient operation of passenger trains of rapidly increasing weights and at high speeds, led to the addition of the high-speed reducing valve and the increase from 70 pounds per square inch to 110 pounds per square inch in the brake pipe pressure, which changed the quick-action brake into what was known as the high-speed brake equipment. This, for many years, remained standard in passenger service.

With the high-speed brake the practical limit of improvement along the lines previously laid down was believed to have been reached, but now conditions requiring greater safety and protective features began to develop about 1903 and 1904 with a rapidity which made it evident that a turning point had been reached. A review of the conditions then existing and to be anticipated in the near future, together with numerous experiments under the most severe service conditions led to the addition of new features to the existing brake equipment, some of which would have been inherently impossible if the design were carried on along the lines previously followed.

In the case of the passenger brake, the improvements and novel features were in the direction of obtaining:

1. Maximum stopping power.
2. Uniformity of braking power on all vehicles.
3. Maintenance of brake cylinder pressure, notwithstanding leakage.
4. Insurance of proper margin between the power of service and emergency applications.
5. Promptness and certainty of brake application for service stops.
6. Protection against depletion due to careless or prolonged manipulation of the brakes.
7. Graduated release feature to provide for smooth and accurate stops being made.
8. Automatic emergency application on depletion of brake pipe pressure.
9. Maximum emergency braking power available at any time.

A graphic comparison of the effectiveness of the high-speed brake and the improved passenger equipment is afforded by a comparison of the emergency stops possible with the two equipments. From 60 miles per hour a modern 590-ton train can be stopped in 1100 feet with the improved equipment, or 575 feet less than the same train will run if the high speed brake is used. Moreover, the train, if equipped with the high-speed brake, will reach the 1100-foot stake 6 seconds sooner than the train having the improved brake and will pass this stake at a speed of 38 miles per hour, having then the equivalent of 40 per cent of its original kinetic energy at 60 miles per hour. At the time when the train with the improved equipment stopped at the 1100-foot stake, the train with the high-speed brake equipment was 275 feet further on and still running at a speed of 28 miles per hour which corresponds to a kinetic energy 22 per cent of the original amount when the train was running at 60 miles per hour.

The improvements incorporated in the freight brake equipment have been in the direction of insuring greater certainty and safety in the handling of long trains and heavy loads. This has been accomplished by providing for:

1. Ability to apply and release the brakes without fear of shocks on the longest trains.
2. Effective and uniform braking power obtained for comparatively light reductions.
3. Uniform release of the brakes on the train as a whole, thus avoiding shocks due to the brakes on the forward end of the train releasing while those at the rear still remain applied.
4. Uniform recharge feature largely increasing the factors of safety and effectiveness.
5. Economy in air consumption resulting from effective and uniform braking effort being obtained on each vehicle in the train for a comparatively light reduction.
6. Improved type of freight triple valve designed to work in harmony with the older valves, insuring a largely increased efficiency of the brake with new and old style valves, mixed in the same train.
7. One form of equipment is especially designed to give an increased braking power in proportion to the load carried and proportionate increase in the ability to handle trains of loaded cars, especially in freight service.

The improved features of the locomotive brake are not only complementary to those already mentioned in the case of the passenger and freight car equipments, but include certain operative features, long recognized as desirable but remaining impracticable until the establishment of a new basis of design permitted the including of all that previous experience had shown to be desirable in a compact and mechanically satisfactory combination of parts. These features include:

1. Either entirely independent or simultaneous operation of the train and locomotive brakes as may be desired, adding greatly to the convenience and flexibility of handling long trains, especially on grades, in switching, etc.
2. Predetermined and maintained brake cylinder pressure irrespective of leakage, number of brake cylinders, or variations in brake-piston travel.
3. Predetermined and desired increase in emergency-brake cylinder pressure over the maximum obtainable in service.
4. Automatic protective feature insuring against the loss of the brake through careless manipulation.

The result of this has been that during the last five or six years, complete and distinct types of brake apparatus have been evolved especially adapted for most efficiently meeting the peculiar conditions presented by modern locomotive passenger and freight service, respectively. With the incorporation of these new features, it may be fairly said that the air brake has entered upon a new era of its history as distinct from that which preceded, covering the progress of the art from the development of the plain automatic brake to the high-speed brake, as that era was distinct from those of the straight air brake and of the hand brake which marked the early history of the art.

* * *

LIGHT ALLOYS FOR AIRSHIP CONSTRUCTION

The advent of the airship as a practical means of locomotion has led to considerable competition among the manufacturers of light metals suitable for use in airship construction. At one time, the best metal in Germany was that known as "chromium," manufactured by the firm of Berg; but this material is being superseded by newer metals. Last year several new light metal alloys were judged for adaptability to airship construction at the aeronautic exhibition, Frankfort, Germany, the metal that received third prize, appearing lately to be the favorite. The first-prize metal was that called "electron," which contains upward of 90 per cent magnesium; but from its inability to stand sea water, and its dubious atmospheric resistivity, it has made but little progress on the market, although it has an ultimate strength of 50,000 pounds per square inch, and a specific gravity of 1.8. The second-prize metal, likewise a magnesium product, has dropped from the field. The before-mentioned third-prize metal, called "duralumin," shows every indication of becoming the favorite material of construction for airships, and has received favor from Count Zeppelin, and the British admiralty, both of whom have placed orders for the material. It has also been adopted by Messrs. Vickers' Sons and Maxim, in England, who have the British rights to its manufacture. The ultimate strength is 85,000, with a specific gravity of 2.8; this is much less than the specific gravity of brass, which it is rapidly superseding for such other purposes as cartridge cases, etc. It is sufficiently immune to the corrosive action of sea water to make its use at sea practicable, as experiments have shown.

WHAT IS A MACHINE TOOL?

By T. S. BENTLEY*

The question as to what is and what is not a "machine tool" has been exciting no little discussion of late, and the controversy has shown how widely opinions differ as to what machines may be properly so described and what should be put in some other category. The matter is of more than merely academic interest, as the term is of such importance and so constantly employed that a clear and well-recognized definition is certainly desirable. Accordingly many suggested definitions have been put forward and many diverse views expressed with regard to the question at issue.

Mere opinions on such a subject, if given without intelligible reasons to support them, are usually of little real interest or value. They are likely to be the unconsidered expression of casual preference, resulting rather from association or prejudice than from reasoned thought; while the process by which the significance of a word is fixed is not accidental nor haphazard as are the circumstances which control hastily formed conclusions.

Change there must be in any but a dead language, and nouns are especially subject to it. Verbs are perhaps least affected; the older ones refer to concepts that do not change, and for activities that are new fresh verbs are usually coined. Various writers—notably Herbert Spencer—have pointed out that there is a constant and inevitable evolution which tends first to generalize the meaning of a word, and later to restrict it within closer and more definite limits. Nouns, being symbols for ideas or objects, must of necessity be preceded by the things which they represent. As fresh varieties appear they have to b referred to by means of the nearest names which are current at the time; and the connotation of these words is thereby expanded. In this way the names soon lose their clear-cut significance and assume a general sense more or less vague, indeterminate and tending to ambiguity. This condition, being unsatisfactory, occasions a natural effort to remedy the defect by the use of qualifying phrases and the coining of new words. These actions are at first spontaneous and instinctive on the part of individuals; but after a time the more discriminating among those chiefly concerned commence by conscious and systematic selection to specialize the various terms and restrict each to a more or less definite sphere. The discussion concerning the most fit use of the term "machine tool" is an instance of this particular stage of the process.

Through the action described above, it comes about that words have commonly a general and also a special signification—of which the latter tends ultimately to predominate. This natural sequence explains much that is puzzling in the use and changing meanings of words. It also provides a logical basis for the attitude which we all as individuals are bound to assume in relation to this mental currency.

"Usage" is the final court of appeal in matters of speech, and to its formation all of us contribute in some slight measure. Authorities cannot coerce it; all they can do is to suggest, endorse and finally record the decision unconsciously expressed in the every-day talk of those who speak the language.

One or two examples will render my meaning clear and serve to illustrate the connection between the general rule and the particular instance which we specially set out to consider. Take the word "engine"; this originally signified *any* machine, practically without exception. Our modern phrase "engines of destruction" as applied to artillery suggests its association with the *ballista* and *catapulta* which among the Romans were what cannon are with us. The same broad sense is also preserved in the terms "dividing engine," "rose engine," "engine-turning," etc. The word engine is now practically restricted to certain classes of prime movers which are further differentiated by characteristic prefixes such as "steam," "gas," "oil," "internal-combustion," etc. It is also noteworthy that later forms of prime movers have been designated by other and more distinctive names such as "motor" and "turbine." In the same way the allied word "engineer" soon became so indefinite that some qualifying term is now coupled to it almost as a matter of course. The natural tendency towards ultimate specialization is exemplified, however, in the characteristic use of this word in American railway practice as the equivalent of the English word "driver"—the man in charge of a locomotive.

The word "engine" in its broad sense has been almost entirely superseded by "machine," which is now employed in such a multitude of connections that it must perforce be qualified by some descriptive word—often a participial adjective. Thus it comes about that in common speech we are likely to regard the primary word as redundant, and to shorten the combination by coining a new noun from the descriptive prefix. Hence we speak of planers, shapers, locomotives, etc.

The word "machine" itself has become so far specialized that, in place of meaning *any* mechanical aid, it now conveys the idea of a more or less complex piece of mechanism designed to transmit, transform or apply power in order to achieve some desired result. In like manner the word "tool" has run through a whole scale of meanings and, in a broad sense, is still applied alike to the simplest hand instrument and to some of the most complex machines which equip the modern engineering work-shop.

In general, however, the word "tool" signifies a small appliance for the performance of almost any simple operation. A large number of tools are intended for cutting, but this is not necessarily the case. A hammer is a tool for striking; a file for smoothing; a bookbinder's "tool" serves to impress patterns on leather, while a painter's "sash-tool" is a special brush for painting window frames; but though tools, or mechanical aids, are employed by everyone more or less they are not always known by that name, and it is interesting to note how they have become grouped by common usage under distinctive titles. Thus in the work-shop they are *tools*, in surgery and drafting-room, *instruments*; in the gymnasium, *apparatus;* in the kitchen, *utensils;* and on the farm, *implements;*—yet the word "tool" in its broad sense, covers them all. A similar process of differentiation is now taking place in connection with appliances of a more complex nature.

There have been many definitions suggested with a view to restricting the applicability of the term "machine tool," and on comparing them we discover that they not only differ in phrase but differ still more in the ideas which underlie them. In fact there is no unanimity as to the fundamental conditions which justify the use of the name. Some lay stress on certain characteristics of the machine itself, others on the kind of work which *can be done* on it; but most base their classification on the kind of work the machine *does actually perform* (as distinct from its potential capabilities), and many make the classification dependent on the purpose for which the work is produced. Who could expect agreement from ideas so radically conflicting!

Then again, we must not forget that there are circumstances in connection with the term "machine tool" which tend to render its definition peculiarly difficult by importing into the matter certain considerations other than that of mere philological fitness.

1. There is a vague feeling in many quarters that the name "machine tool" implies a status appreciably superior to that of the class dubbed "machinery." This idea is doubtless a relic of the time when machines were built singly, and those intended for the use of the builder or some other skilled mechanic were naturally more carefully made than such as were destined for those who were less critical or whose requirements were less exacting. Under present conditions of manufacture and use there is no longer the pronounced distinction.

2. The machine tool builders' associations are further embarrassed by the fact that their adoption of a restricted definition might, by implication, challenge the technical eligibility of some of their old and valued members for membership of their body. It is as though the modern definition of what constitutes a surgeon had been suggested for official adoption by the old guild of "barber-chirurgeons" in the days when the barber's pole still had a sanguinary significance and before the "tonsorial artists" had started societies of their own. The latter would naturally and inevitably have opposed any such strict definition because it would make them appear out of

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place where they had long been comfortably settled and desired to remain. Such a distinction between those who plied the scissors and those who wielded the lancet would not only have seemed invidious in what had hitherto been the common name of both, but would also have been difficult of application as many of the members practised both professions and were equally adept at both.

Now for months past thought has been given by many to this question of a suitable definition for "machine tools," yet no satisfactory conclusion has been reached because each suggested formula, when carefully analysed, has proved hopelessly defective. Let us consider some typical examples and try to discover wherein they fail.

A. "*A machine tool is a machine used in the building of other machines.*" This has the merit of brevity, but is at once too wide and too narrow. It would let in the crane or lifting jack while shutting out half the equipment of the toolroom!

B. "*A machine tool is any hand- or power-driven mechanism consisting of several parts, some of which move to perform any process or operation in making tools, machines, structures and the parts thereof, from metal and other alloys and which is not used in nor based upon other mechanisms to make it operative.*" While this is studiedly comprehensive it is too long for popular adoption and does not appear to do what is intended after all. The steam or self-contained pneumatic power-hammer would certainly come within its scope, but most of the portable machine tools which form so useful a feature in many modern shops would seem to be ruled out.

C. "*A machine tool is any hand- or power-driven unitary mechanism actuating cutters, tools, dies or other forming or shop implements, to perform any process or operation in making tools, machines, structures or any part thereof from metal, in distinction from one for producing a special or specific article.*" This is still too long for convenient use even if it adequately met every other requirement. It is not free from ambiguity, and might to taken to shut out the automatic screw machine though probably not so intended. It will be noted that this last definition lays stress on a characteristic which neither of the others referred to; and therein, to my mind, its principal value lies.

It is generally recognized that no satisfactory definition can be based on features of design or construction because the immense variety of machines to be covered makes any such attempt either hopelessly inadequate or too unwieldy for use. Besides, as new developments are constantly taking place, any such definition would speedily become obsolete. For this reason also, any attempt to solve the question by compiling lists of what should or should not be styled "machine tools" is foredoomed to failure.

Definitions making the particular work on which the machine is engaged the deciding factor will not stand analysis; neither will those which regard the ultimate use to which such product is to be put as the crucial point. These schemes involve such anomalies as that two similar machines working side by side might have to be classified differently, and if for any reason the distribution of work should chance to be reversed, then the classification would need to eb altered! Any such plan is manifestly absurd; a definition must be based on something less accidental and liable to change. It must rest not on a detail but on a principle.

Another idea seems more hopeful, and I will illustrate it by analogy. Suppose three men, A B and C are employed in the same shop. It may happen that we find A and B doing precisely similar work but that B stands higher than A on the pay-roll. B is more highly valued because he can do other work also—he is a "good all-round man"—while A is at a loss except on his usual job. But C may be rated equal with B although he does not profess to be an all-round man, and in fact always keeps on one class of work. He is valued as a *specialist* in his line. This seems to me a fair illustration of the principle on which our classification must be based. A may stand for the ordinary machine of no particular class; B for the "machine tool"; and C for the special machine, the two latter being equally valued for opposite reasons, as representing range of capacity on the one hand and concentration on the other. Thus the single-purpose machine is not necessarily inferior to one of greater adaptability—each must be judged on its merits.

One of the few points on which all suggested definitions appear to agree is that wood-working machines should be barred out. This seems to be either expressed or implied in every formula. Why are they excluded? A carpenter's mortise chisel, for example, is undoubtedly a tool. A mortising machine employs a similar tool or performs the same kind of work. Why then may it not be styled a "machine tool"? This distinction is a matter of some interest. Is it also a matter of principle—of widespread prejudice—or is it merely a coincidence?

Personally I believe it is neither, but that it is due primarily to convenience. Wood-working machines are so specialized that each is most conveniently referred to by its own particular name; so this is done naturally and as a matter of course. The general term is dropped not so much "on principle" as because it serves no useful purpose. It is just the same with the men in the shop. Suppose I needed more help in the press tool department I should not advertise for "a man," although I should expect to get one; nor for a "mechanic," as that may mean almost anything; even the word "toolmaker" would be too vague. The description "press-tool-maker" gives all necessary information at once and *does not deny, but includes* all the other terms. Therefore, they would not need to be employed in this connection.

This brings me to my final point, *viz.:* that the disagreement as to a definition is really inherent in the way the question is put. I would restate it as follows: "*Which machines should be called 'machine tools,' and which should be more definitely named?*" In this way the problem is changed from the negative to the positive; and, put into quite a different perspective. This method avoids all cause of embarrassment or offence, harmonizes with the natural process of evolution, and thus has every chance of resulting in an amicable and permanent agreement.

If space would permit, it would be extremely interesting to trace this same natural process in the evolution of all our standard machine tools. Although now so dissimilar in character and function, they are in fact all sprung from that machine tool *par excellence* the lathe, each function of which has been separately developed and specialized until in some cases all apparent relationship has been lost. The names have kept pace with the development and many of those indicating the descent, being no longer necessary, have dropped quietly out of use in favor of more special terms. But even a special title may become a misnomer—as in the case of the automatic screw machine—and call for revision. The machine referred to was designed for a specific purpose and designated accordingly, but its capabilities have been so greatly extended that it has really reverted to the class of general machine tools though still retaining its special name.

That these principles are of general application may be illustrated from quite another field. Any army officer is commonly referred to by his distinctive rank. This does not in any sense deny that he is a soldier—quite the opposite—but the usual practice is so well understood that the more indefinite term (except when used in an obviously general sense) is left almost entirely to the "rank and file." The army also furnishes examples of special terms which have now become general or at least divorced from their original and literal significance; for instances take fusileer, grenadier, etc.

These considerations force me to the conclusions:

a. That wherever a machine is so modified as to be restricted to one kind of work, it should be described by a name which makes this clear, in preference to an indefinite one.

b. That machine tool builders should agree together as to the general adoption of such special names and their employment in all printed matter, advertisements, etc.

c. That this course would aid the natural solution of the problem by setting up an influential usage which would stand every chance of being generally followed.

Similar concerted action might with advantage be taken to establish a well-defined use of certain important words at present very loosely employed—as for instance, "automatic," "universal," etc., which are at present decidedly ambiguous.

If the machine tool builders' associations would take this matter up in earnest, they would be doing signal service for the benefit of all English-speaking peoples; for the highest stages of any nation's progress depend on and are limited by the scope and clearness of the language spoken. Those, therefore, who count their mother tongue a priceless heritage, and strive to guard it as a sacred trust, not only serve *their* generation well, but win the thanks of others yet to come.

INTERESTING TOOLS AND METHODS OF CINCINNATI SHOPS*—6

THE AMERICAN TOOL WORKS CO.

By ETHAN VIALL†

The American Tool Works Co., of Cincinnati, manufactures a greater variety of machine tools than any other firm in that city, its line comprising lathes, planers, shapers and radial drills; in addition, it manufactures all the countershafts used in connection with its output. The shop practice of the different departments devoted to the various lines is equal in every respect to that of the single-specialty shops. All shafts or other cylindrical parts requiring smoothness and accuracy are ground and, if necessary, lapped. High-speed pulleys and flywheels for motor-driven planers or other purposes are given a standing balance and then a running balance on a Defiance balancing machine, which is one of the few balancing machines of this type the writer has seen outside of automobile factories. The heating and power boilers are fired with natural gas which is cleaner, cheaper and causes

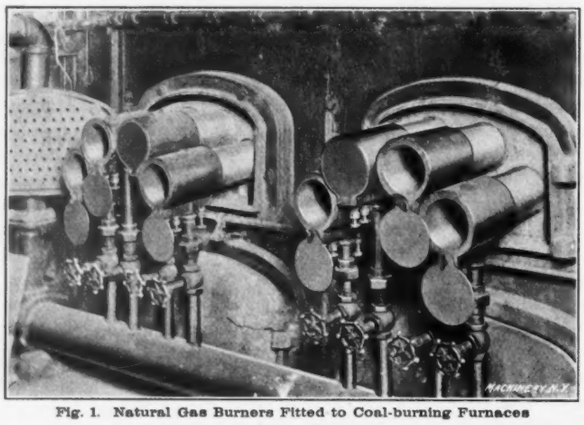


Fig. 1. Natural Gas Burners Fitted to Coal-burning Furnaces

less trouble than coal, besides doing away with the smoke nuisance that is such a factor in some cases. A view of one corner of the boiler room, showing the method of applying gas burners to boilers that were originally coal-fired, may be seen in Fig. 1.

Hobbing Teeth in Radial Arms

Probably as interesting to a mechanic as anything in the shop, is the way the worm-gear teeth are hobbed out on the universal arms of large radial drills. The large end of the radial arm is first turned to the right diameter, the end finished and the center hole bored, after which it is bolted down and the worm-gear teeth hobbed as shown in Fig. 2. In Fig.

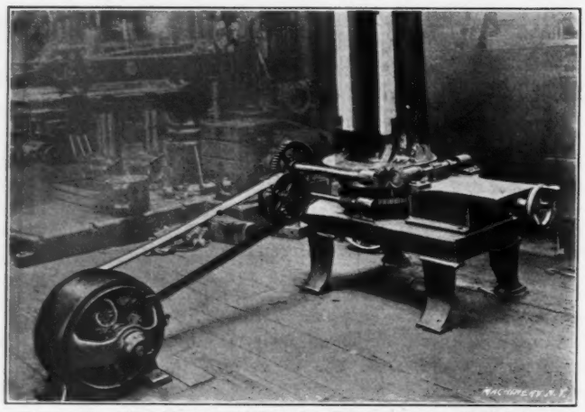


Fig. 2. Complete Machine for Hobbing Worm Gears on Radial Arms

3 the mechanism is shown more in detail. *A* is the table of the machine (driven by means of the worm and worm-gear *B* and *C*) to which the arm is clamped by the bolt *D* which runs through the center and is held by a nut underneath. The hob *E* and its arbor run in boxes on the carriage *F*, which is fed in or out by a handwheel, the shaft *G* being splined and keyed to the gear *H*, so as to allow the shaft to slide in or out as the carriage is moved. Power is supplied by a 2 horse-

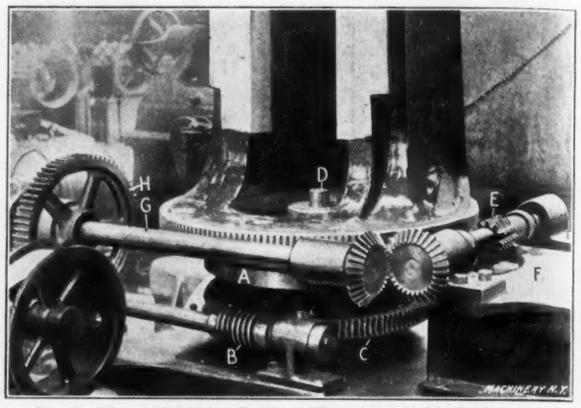


Fig. 3. View of Working Parts of Worm-gear Hobbing Machine

power Westinghouse motor through a belt and gearing as shown in Fig. 2.

Planing the Saddle Slides

The saddle slides for the universal head are finished after the arm and girdle have been fitted together, as shown in Fig. 4, by inserting a mandrel *A*, into the girdle *B*, and then mounting it on two V-topped angle-plates like *C*. The arm is then leveled and lined up from the bored hole in the center, and clamped securely. It is then ready for planing.

Machining Cone Pulleys

Cone pulleys of several sizes and types are first caught by the large end in a three-jaw chuck and the small end is bored

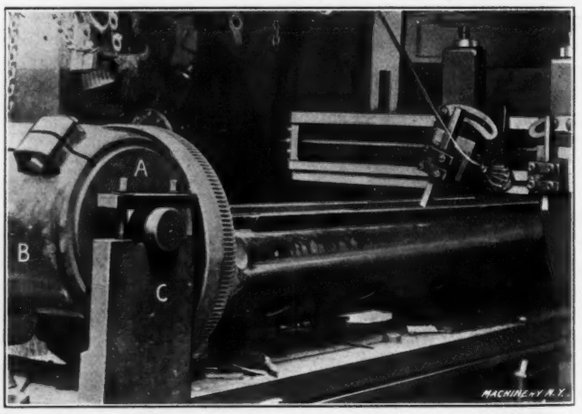


Fig. 4. Method of Mounting Radial Arms on Planer to plane Saddle Slides

and faced. After this operation they are put on a mandrel, with a nut on the outer end which clamps the pulley like a bolt, and all the steps are roughed off at once, including the faces, with a gang of tools, as shown at *A*, *B*, *C*, and *D*, Fig. 5. Tool *E* in the full-swing rest, is used to face the large end. The crowning is a separate operation and is done by using a former made of a flat piece of steel of the required width, the cutting edge of which is slightly concave; this forms each step separately, the tool being held in a special tool-block on the cross-slide. In order to make them balance properly and run smoothly, lathe cones and others without internal spider bracing or webs, are bored out inside on a big turret lathe, the tools for which are shown in Fig. 6. *A* is the chuck which is fastened to the lathe faceplate and into which the cone pulley is placed, large end out, and clamped by the two screws *B*, one on each side of the chuck. *D* is the boring tool used; this is held in the turret, and is steadied while cutting not only by the opposing blades but also by the pilot *E*, which fits a guide bushing in the lathe spindle. While different cone pulleys are shown in Figs. 5 and 6, the method of machining is essentially the same for both types.

* For previous installments of the series on Cincinnati shops, see Bradford Machine Tool Co., November, 1910, engineering edition, Cincinnati Shaper Co., July 1910, G. A. Gray Co., February, 1910, engineering edition, Lodge & Shipley Machine Tool Co., December, 1909, and R. K. LeBlond Machine Tool Co., November, 1909.

† Associate Editor of MACHINERY.

Cutting Internal Gear Teeth in Lathe Faceplates

An "American" planer has been fitted up to cut internal gear teeth in the simplest and most ingenious way imaginable as shown in Figs. 7 and 8, and the particular job for which it is intended is to cut the internal teeth on large lathe faceplates. The two sizes of faceplates that are machined with the device shown in the engraving are 30 and 36 inches in diameter, 86 and 102 teeth, though other sizes may be cut by substituting different index plates. Fig. 7 shows a faceplate

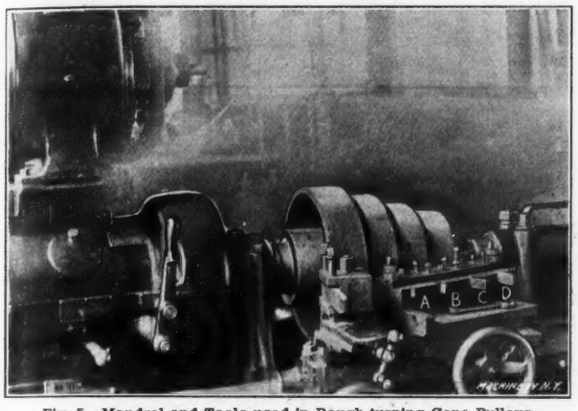


Fig. 5. Mandrel and Tools used in Rough-turning Cone Pulleys

in the cutting position, and it will be observed that except when being indexed the gear does not move, the necessary feeding being done from the tool carriage *A*, mounted on the platen of the planer, the cutting tool *B*, being held in a clapper-box *C* which is fed down by turning the ball-crank *D* by hand. The proper depth to feed the cutting tool is gaged by the templet *E*, which is set into the slot in the bed directly under the tool, but no other stop than the regular reversing mechanism of the planer is needed to gage the tool-travel.

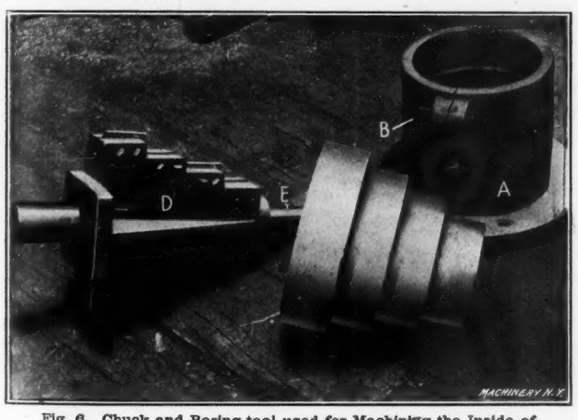


Fig. 6. Chuck and Boring-tool used for Machining the Inside of Cone Pulleys

Fig. 8 is merely a rear view showing the position of the indexing dial, but Fig. 9 shows the fixture removed from the planer housings and gives a good idea of its construction. From the foregoing engravings it will be seen that in order to apply this device, the regular cross-rail must be removed from the planer and these fixtures clamped to the housings in place of it. In the following description of the parts shown in Fig. 9 the letters indicate the same parts as in Fig. 7. *F* and *G* are latch-pin levers for operating the pins that engage the holes in the index plate *H*, the lever not in use being blocked up to prevent the wrong row of holes being used; *I* is a shaft on which is mounted a worm meshing into the worm-gear on the shaft carrying the index plate and internal gear to be cut, so that when the latch pin is out of the hole in the index plate, the parts may be rotated enough to bring the next index hole in line with the pin by turning the hand crank on the end of the shaft carrying the worm. *J* is a special cross-brace used to steady the gear while under a cut, a capstan screw *K* supporting a point on the faceplate directly back of the nose of the cutting tool.

Scraping and Fitting Stands

Two very simple and convenient scraping and fitting stands used in the lathe carriage section are shown in Fig. 10. The lever-wrench used to operate the lock-nut on the tilting-axis clamp may be removed for convenience when working, but it cannot be carried away and lost, as it is fastened to the stand by a small chain, which is an idea that might be followed with profit for many purposes by shops in general. Another style of stand, or rather table, is shown in Fig. 11, which is not only convenient for fitting work of various kinds but is also very handy for various special small machine jobs or repair work which can best be done by using angle-plates and air or electric drills, and a table of this kind should be of considerable value to a jobbing shop.

Graduating Drill Spindle Sleeves

Sleeves for drill spindles are graduated between the centers of a special machine shown in Fig. 12. In this engraving *A* is the sleeve, which has been slipped over a mandrel; *B* is the graduating tool and holder; *C* is the handwheel on the end of the cross-slide screw of the carriage, and *D* is the lever which operates the entire mechanism. Suppose, for instance,

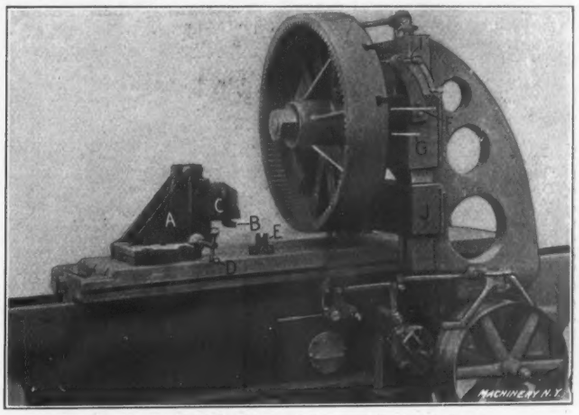


Fig. 7. Planer Fitted for Planing out Internal Gears

that a sleeve is being graduated: The tool carriage is set at the right end of the sleeve and feeds to the left, and by pushing down on lever *D* the connecting-rod *E* is pulled up, making the lead-screw that actuates the tool carriage rotate to the left, causing the carriage to move to the left an amount equal to the distance between the graduations for which the machine is set, the screw being right-hand as usual. As lever *D* is raised, the part *F* comes in contact with pin *G* which causes *H* to rise and rotate the spindle and sleeve sufficiently

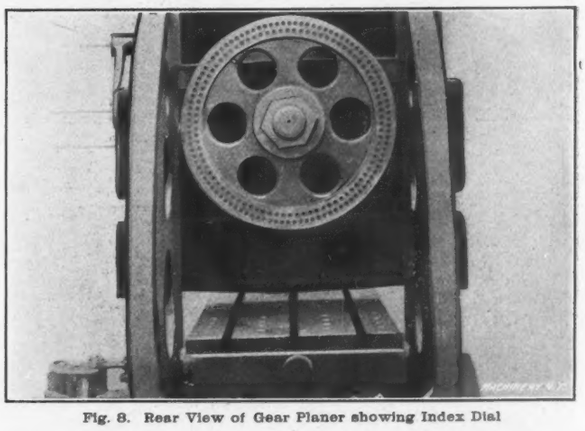


Fig. 8. Rear View of Gear Planer showing Index Dial

to give the required length of graduation; this length is determined by the depth of the slots in the cam-wheel *I* which is rotated on the downward stroke by the dog *J*. The lever *K* is used merely to assist in the working of the spindle and sleeve and is manipulated by the left hand while the right operates the other lever.

Fig. 13 shows a gear testing machine, which, in a general way, is of the usual design but which was made in the shop.

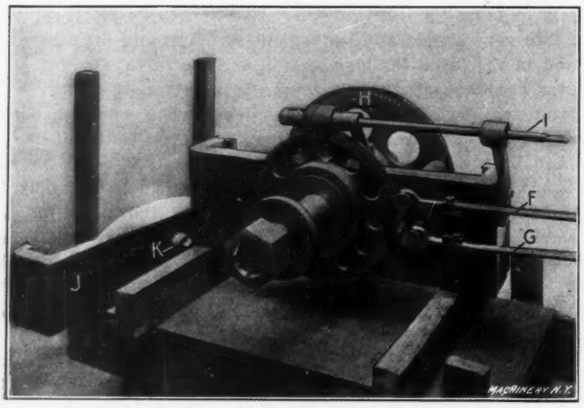


Fig. 9. Gear Indexing Mechanism Removed from Planer to show Details

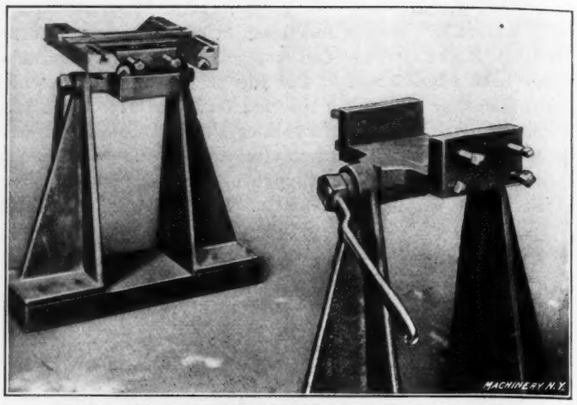


Fig. 10. Scraping and Fitting Stands used to hold Work in Erecting Department

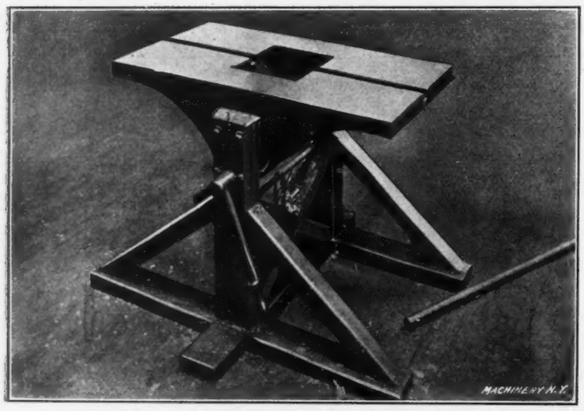


Fig. 11. Adjustable Fitting and Work-table for All-around Use

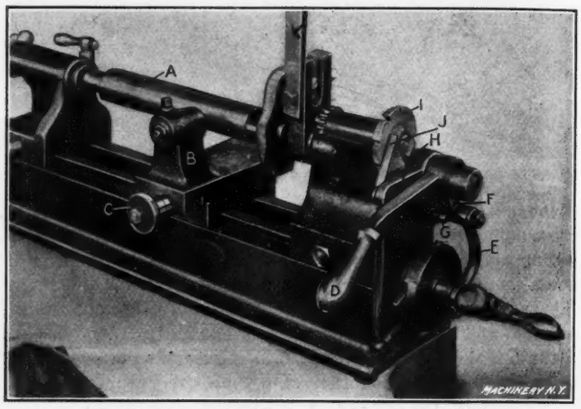


Fig. 12. Special Machine used for Graduating Drill Spindle Sleeves

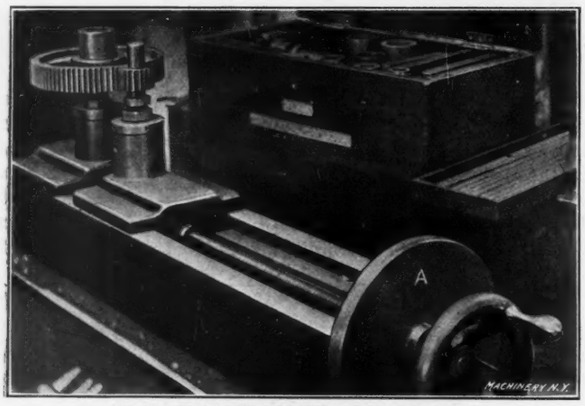


Fig. 13. Gear-testing Machine with Extra Large Graduated Dial

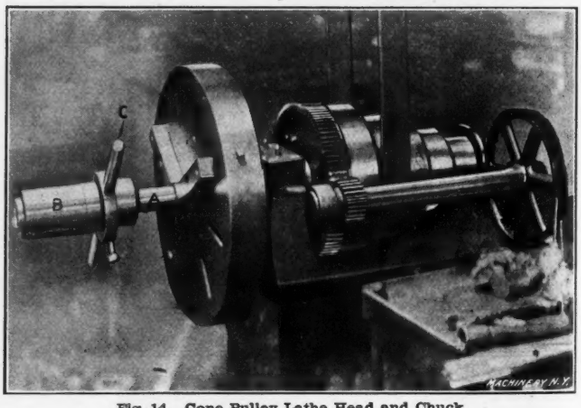


Fig. 14. Cone Pulley Lathe Head and Chuck used for Reaming

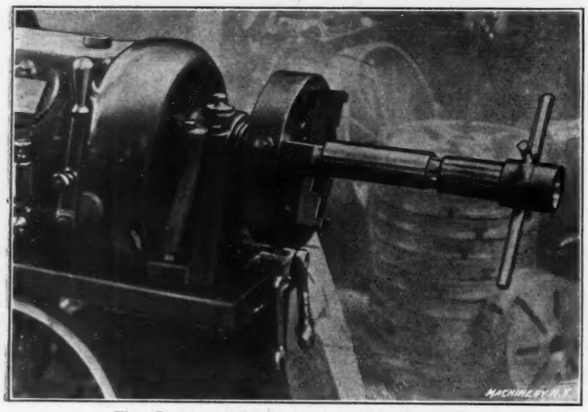


Fig. 15. Geared Lathe Head used in Same Way as in Fig. 14

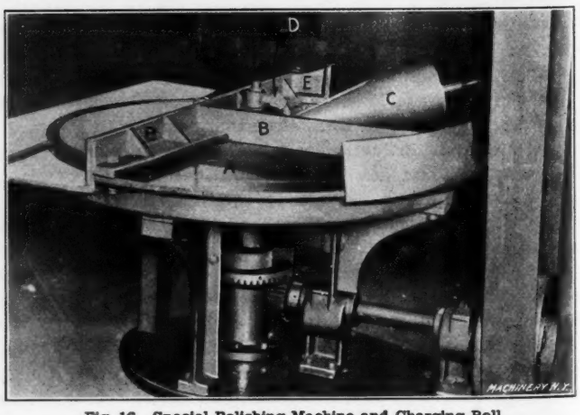


Fig. 16. Special Polishing Machine and Charging Roll for Polishing Flat Work

University of Iowa 7 JAN 1911

A feature of the machine is the large graduated dial *A* on the adjusting screw, which was cut from a precision master screw.

Reaming Heads

A rather novel use is made in this shop of lathe heads as reaming machines for reaming out bushings and other small parts. Fig. 14 shows a cone head with a three-jaw universal chuck, mounted on a stand. A reamer *A* is secured in the chuck and a bushing *B* held by a hand wrench *C*, is shown on the end of the reamer. Fig. 15 shows a geared head used for similar work.

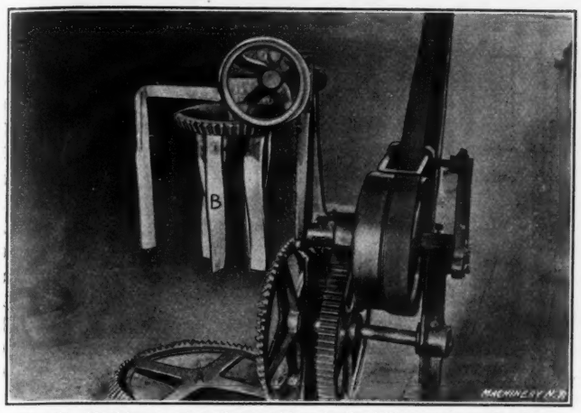


Fig. 17. Machine used to thoroughly mix the Filler made in the Shop

A Machine for Polishing Flat Work

Flat work of various kinds is polished on the machine shown in Fig. 16. The polishing disk *A*, of a special composition charged with emery, is four feet in diameter, and the cross pieces *B* are intended to steady the work being polished. The charging roll *C* held by the swinging hinge *D*, is "hooked up" onto the bracket *E* when not in actual use. For all-around use this machine is one of the best that the writer has seen.

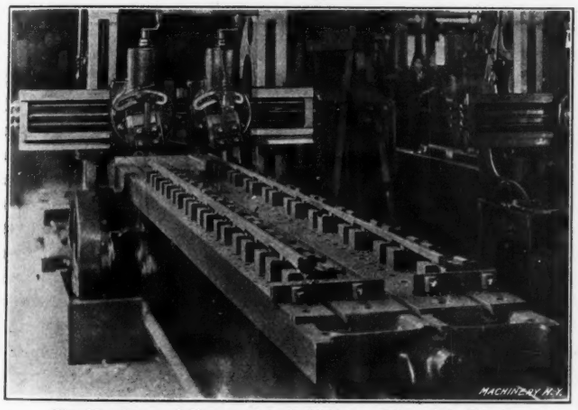


Fig. 19. Gang of Jigs used to hold Taper Gibs while Planing

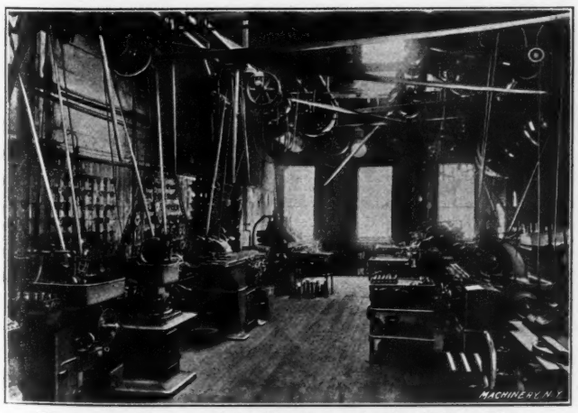


Fig. 21. Partial View of Grinding Room showing Different Types of Grinders in Use

Making Filler

So much trouble was experienced by this company in obtaining a filler that would not check or flake off that they have made their own for some time, from a special formula. The mixer used for stirring the ingredients thoroughly is shown in Fig. 17. In this engraving the can containing the filler mixture is set on the gear *A* and rotated while the mixing paddles *B* rotate in the opposite direction.

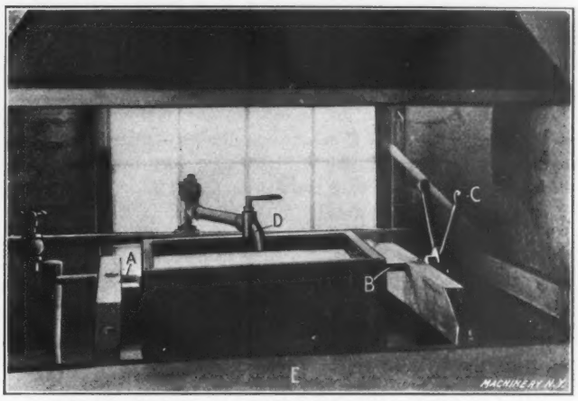


Fig. 18. Rocking Tank used to hold Acid for Recutting Files

Recutting Files with Acid

Fig. 18 shows a wooden tank used to hold an acid mixture for recutting old files. This tank is suspended on the shafts *A* and *B* and is rocked back and forth by means of the capstan *C*. The water faucet *D* may be swung out of the way when rocking or emptying the tank. A large tank *E* retains all acid slopping over or being emptied from the smaller one.

Taper gibs are placed in special jigs and planed in gangs as shown in Fig. 19. Fig. 20 shows two swinging grinders used for smoothing up rough castings.

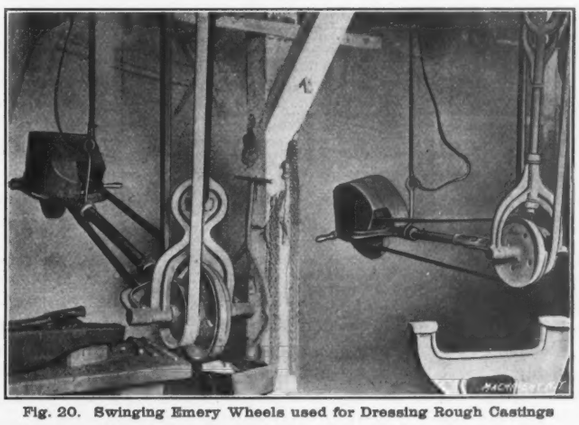


Fig. 20. Swinging Emery Wheels used for Dressing Rough Castings

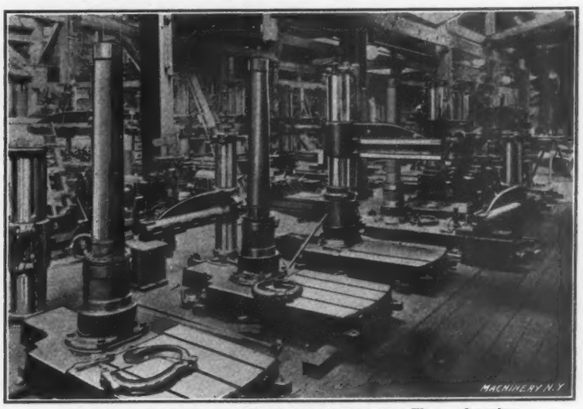


Fig. 22. One Corner of Radial Drill Erecting Floor showing Partially Assembled Machines

As intimated at the beginning of this article, grinding plays a very important part in the manufacturing processes, and

the grinding room is one of the most complete in the West. A partial view of this room is shown in Fig. 21 and Fig. 22 shows one corner of the radial-drill erecting floor. More comprehensive views of these rooms could not be shown because the large amount of work on the floor interfered with the placing of the camera.

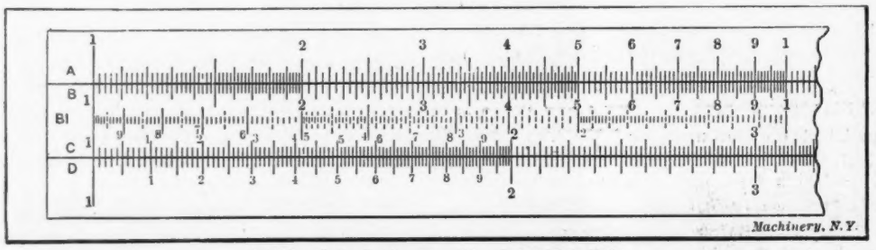
* * *

AN IMPROVEMENT ON THE MANNHEIM SLIDE RULE

By DESIGNER

Herewith is an addition made by the writer to a Mannheim slide rule, which greatly extends its field of usefulness. Anyone taking the trouble to make this addition to his slide rule, provided it is of this type, will be well repaid, and will find it to be a valuable asset.

The improvement consists of a reversed scale placed on the slide beneath what is usually designated as the *B* scale and divided exactly as the *A* and *B* scale; but, instead of commencing at the left and increasing numerically to the right, it commences at the center index and increases numerically to the left, making a scale reciprocal with *B*. This graduation may be accurately performed in the following manner: Invert the slide in the rule so that scale *C* is in contact with scale *A* and, having the index lines in perfect alignment, mark



Additional Graduations on Mannheim Slide Rule

on the slide between scales *B* and *C*, using the divisions on scale *A* as a guide.

For a marking instrument use either a very sharply pointed needle or a knife, making use of a small toolmaker's try square placed along the upper edge of the rule to accurately position the lines on the new scale, which may be designated B_1.

The best method of making divisions, owing to the space being limited, is to make short straight lines for the main divisions and three, two and one prick marks for the subdivisions. After the markings have been made, take red ink and fill in each line and sub-division.

When the ink is dry use a damp, cleaning eraser to remove the surplus ink. The lines and points scratched in the celluloid facing will then stand out very clearly. If this method of division is used, the new scale may be marked as accurately as the original graduations.

After completing the marking, restore the slide to its normal position, and the rule is then ready for use. Besides having all the advantages of the duplex and the multiplex rules it has several exclusive ones; some of these are given herewith:

Multiplication of three numbers at one setting thus: Set the first number on B_1 to the second number on *A;* above the third number on *B*, read the product on *A*.

Multiplication of five numbers at two settings thus: Set first number on B_1 to second number on *A;* above third number on *B* set glass runner; set fourth number on *B* to glass runner; and above fifth number on *B*, read the product on *A*.

Division of one number by two numbers at one setting: Set one divisor on *B* to dividend on *A;* above the other divisor on B_1, read quotient on scale *A*.

Reciprocals are read directly; the reciprocal of a number on *B* will be found directly below on B_1, and *vice versa*.

In addition to these, there are many other settings that reduce the number of operations necessary on the ordinary Mannheim rule. These can be developed by the operator as necessity demands, as the range of this new scale is quite extensive.

LIMITATIONS IN DESIGN OF THE WÜST HERRINGBONE GEAR

By PERCY C. DAY*

The article on the limitations in design of the Wüst herringbone gear by "Charles Augustus," published in the December issue of MACHINERY is rather misleading. In the first place, the Wüst gears have not been brought out very recently, but have been extensively used in Europe, particularly in Great Britain, for the past six years.

It is true that these gears may be cut just as accurately on an ordinary hobbing machine as on the special double hobbing machine developed by Mr. Wüst, "if the proper form of cutter is provided and the proper indexing mechanism used." Those who are familiar with the production of these gears will appreciate the significance of the reservation. That Wüst gears can be just as accurately cut on an ordinary milling machine or spiral gear-cutter is incorrect. Helical gears cut by such methods, which necessitates the use of formed cutters, cannot be compared with Wüst gears generated by hobs.

The spiral angle of Wüst gears is not necessarily 23 degrees, although this has been adopted as a standard, as it makes a very satisfactory compromise between ideal running and the best manufacturing conditions. As a matter of fact, gears have been cut with a spiral angle of 30 degrees which cleared satisfactorily at the center.

In figuring out clearances, "Charles Augustus" seems to have omitted to allow for the fact that Wüst gears are usually cut with short addendum. There are many disadvantages in the adoption of a large spiral angle. It is perfectly true that the wear on the teeth for a given load is considerably greater with a spiral angle of 45 degrees than with 23 degrees. It is also true that the normal component of tooth pressure is greater and the normal tooth section is less with the higher angle. It is obvious that some fixed standard of spiral angle must be adopted by those who manufacture this type of gear, and the angle of 23 degrees is that which gives the best average results for the varied uses to which the gears are put. Wüst gears are used for the heaviest pumping, rolling and hoisting work as well as for high-power steam turbines where the pitch line velocity often reaches from 5000 to 7000 feet per minute. In nearly all cases where the gears are applied, it is possible to adapt the face width to suit the running conditions. Even in those cases where the available face width is narrow and the gears are required to run at high speeds, it is usually found to be a better solution to decrease the pitch than to increase the spiral angle. For gears of fixed diameter, load, speed and face width, a decrease of pitch, by distributing the load over more teeth at one time, will generally secure quiet operation with less wear and tear than if an attempt is made to meet the conditions by increasing the spiral angle. Not, by any means, the least advantage of the 23-degree angle lies in the fact that it admits the use of hobs which do not require to be set round but are made of the same angle as the teeth. This method allows the hob axis to be set perpendicular to the gear axis, so that the teeth are generated from the true rack section of the hob.

While there is no particular advantage in the staggered form of tooth where the number of teeth in gear and pinion lies within the ordinary limits, it must be borne in mind that Wüst gears are used for exceptionally high ratios and it often happens that a pinion of seven or eight teeth is used. In such cases the staggered form of tooth has a great advantage in securing the desired continuity of engagement without excessive face width. It is, of course, quite feasible to cut out the non-bearing portion in the center, but this only adds to the expense and it does not avoid the necessity of staggering the teeth to enable the cutters to clear.

* * *

Gravitation never kept a man from rising in the world.

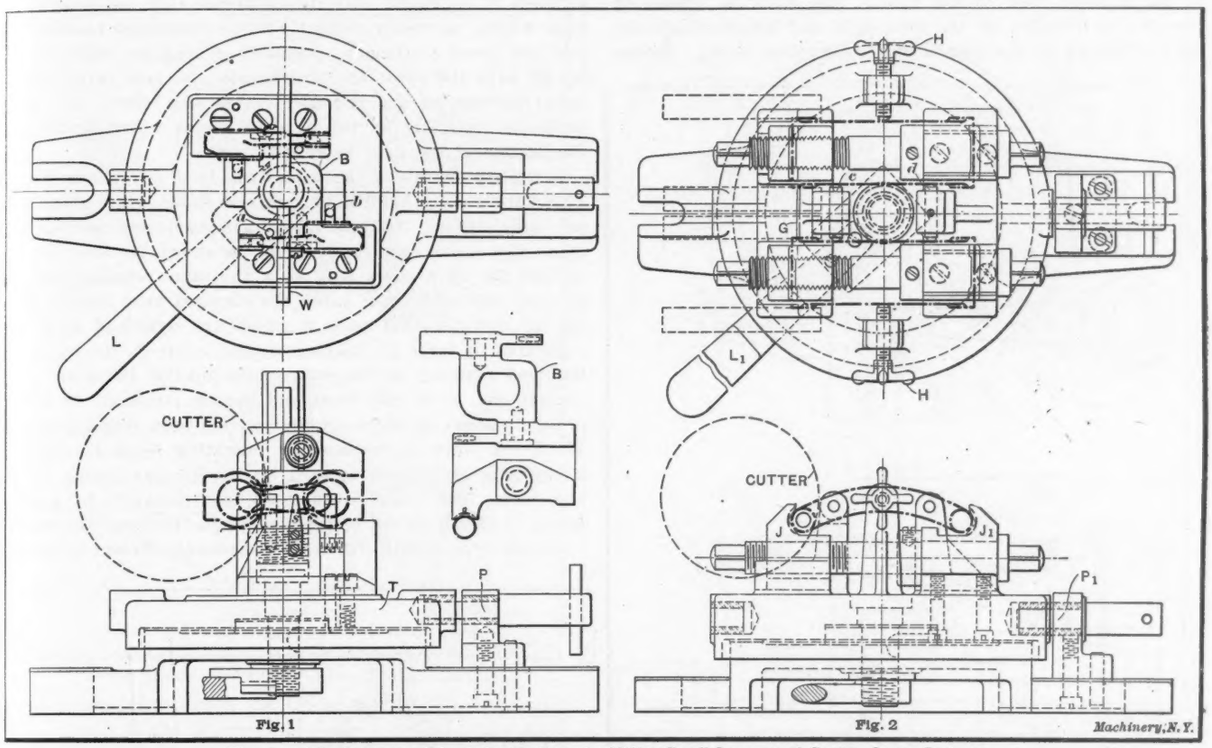
* Address: The Falk Co., Milwaukee, Wis.

SOME JIG AND FIXTURE DESIGNS*

EXAMPLES FROM TOOL DESIGNING DEPARTMENT OF TAFT-PEIRCE MFG. CO.

By FRANKLIN D. JONES†

The ingenuity displayed in the designs of many of the jigs and fixtures which may be seen in almost any up-to-date shop, compares favorably with the skill required in other work which would appear, at first thought, to be of a much higher order. The factors which must be considered in the design of an efficient jig or fixture, such as the facilities for inserting, clamping, and removing the work, accuracy, strength, lack of complication, cost, etc., require not only good judgment, but also an intimate knowledge of shop methods. As the various elements which should be considered in connection with this work have been discussed at length in previous contributions that have appeared in these columns, this article is intended to supplement those which have preceded, by the detailed description of a number of jig and fixture designs that have proved satisfactory in service and doubtless contain features that may be applied in a variety of ways by designers engaged on this class of work. The various designs illustrated are used on automobile work and all are the product of the tool-designing department of the Taft-Peirce Manufacturing Co., Woonsocket, R. I.



Figs. 1 and 2. Fixtures of the Indexing Type for Milling Small Levers and Control Lever Sectors

Fig. 1 shows a fixture that is used for gang milling small side-control levers. The work, in this illustration, is indicated by heavy dot-and-dash lines, the engraving being similar in this respect to the others accompanying this article. This fixture is of the indexing type, the work being clamped to a circular table *T* which may be rotated. The table is loosened or held firmly to the base by operating the hand-lever *L*, and

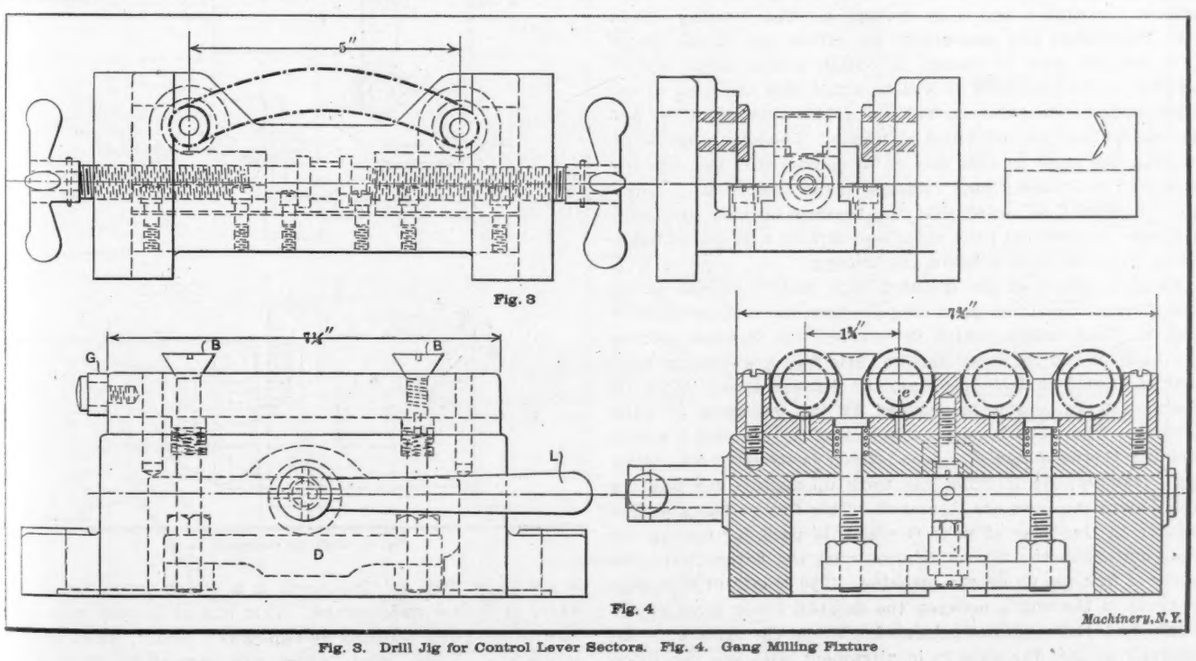


Fig. 3. Drill Jig for Control Lever Sectors. Fig. 4. Gang Milling Fixture

* For additional information on this subject, see the following articles previously published in MACHINERY: Pertinent Points on Jig and Fixture Design, August, 1910; Proper Designing of Milling and Drilling Fixtures and Jigs, May, 1909; and the series of articles on Jigs and Fixtures beginning April, 1908, and ending April, 1909.

† Associate Editor of MACHINERY.

it is accurately located in two positions, 180 degrees apart, by the indexing pin *P* which engages either of the two holes in the table, as shown. The work is clamped by driving a wedge *W* which forces down a central block *B* on each side of which clamps, free to swivel, are mounted. By having these clamps free to rotate, the pressure on the ends of the work is equalized. The form of these clamps and the way they are attached to the central block, is more clearly shown in the detailed view to the right. The work is located in this fixture laterally by the pins *a*, *b*, and longitudinally by the V's formed in the clamps and supporting blocks. Before

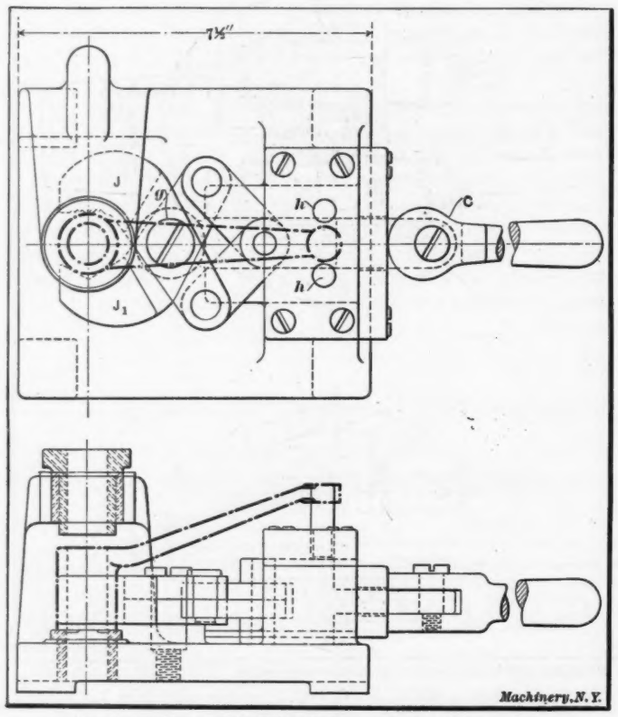


Fig. 5. Drilling and Reaming Fixture with Toggle Clamping and Locating Jaws

the clamps are tightened, the two levers to be milled are held against the pins *a* and *b* by springs *s*. The locating V's in both the clamps and base-blocks are milled out in the center (see detailed view of clamp) to obtain a firm grip. By referring to the plan view it will be noted that the ends of the work vary considerably in width and also that one wide and one narrow end are machined at a time. The advantage of arranging the work in this way is, of course, that the opposite ends will be in the proper relation to the cutters after indexing. It should be noted that the bearing between the table and base is protected from chips and dirt by a guard or flange which projects ½ inch below the bearing.

Another fixture of the indexing type that is similar to the one referred to in the preceding paragraphs, is illustrated in Fig. 2. This fixture, which is intended for straddle milling the hubs of control lever sectors, also has a swiveling table that is located in two positions, 180 degrees apart, by an indexing pin P_1, and it is clamped by the operation of hand lever L_1. The work is accurately located by the pins *c* and *d*, and the V-jaws *J* and J_1, one of which is movable for clamping. Hand-screws *H* bring the work up against the locating pins before the jaws are tightened. This fixture has a unique feature in the form of gage *G* which is used for setting the gang cutters in the correct relation with the fixture when the latter is first set up on the machine. The length of this gage is equal to the width between the finished inner faces of the work, and it is centrally located. When the fixture is set laterally so that the gage is in alignment with the two interlocking cutters in the center, the bosses on both sides of the work will be finished to the same height on the first piece milled. By this method the number of improperly-finished parts is reduced to a minimum, and the time consumed in setting the fixture by the cut-and-try method is eliminated.

Fig. 3 illustrates a jig for drilling the bosses of the sector shown in the fixture, Fig. 2. It will be noted that V-jaws are also employed in this jig for clamping; in this case, however, both jaws are moved in unison by a right- and left-hand screw, held stationary—as far as longitudinal movement is concerned—by two thrust collars in the center, and operated by handwheels at the ends. The object in having both jaws movable is to locate the casting in a central position regardless of its length, with the advantage that the holes at the ends will be as nearly central with the bosses as possible. If one jaw were stationary, obviously a long or short casting would have the error all on one side, the hole being central with the boss at one end and out at the other. The work is located laterally by the finished bosses which fit between the flanges of the drill bushings.

A milling fixture of the gang type is illustrated in Fig. 4. This fixture is for holding four reverse tubes, while oil grooves are being milled. As these tubes have previously been splined, small pins *e* are used for locating, as shown in the end view, so that the oil grooves will be in the same relative positions in each case. The four tubes are clamped by a similar number of conical-headed bolts *B* which are tightened by a cam (operated by lever *L*) bearing against a bar *D*, the bar being mounted centrally on two connecting links at the ends. This central bar is of cast steel and spring tempered to give a certain amount of resiliency, this having been found desirable. When the work is released by operating lever *L*, the four clamp-bolts are forced upward by the springs shown in the end view. The tubes are located longitudinally by gage *G* which is swung up out of the way when "loading" the fixture.

An odd type of drill jig which has proved efficient in service,

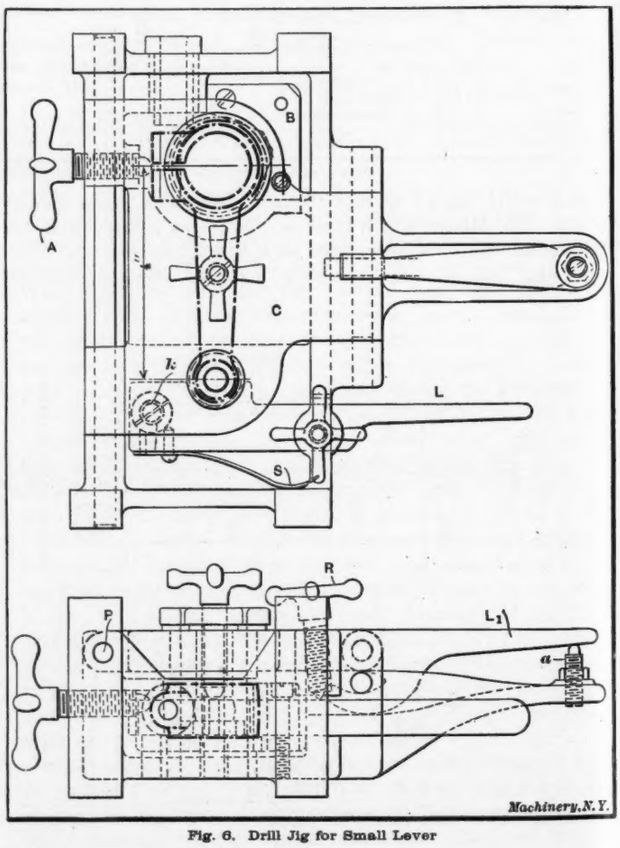


Fig. 6. Drill Jig for Small Lever

is shown in Fig. 5. The work is a clutch lever, the hub of which is drilled and reamed. This hub is located with reference to the guide bushing by two jaws *J* and J_1 which also act as clamps. These jaws, which are pivoted on stud *g*, are moved in unison by the double cam lever *C* which actuates a sliding block, connected to the jaws by the links shown, thus forming a toggle which gives considerable clamping power. The small end of the work is steadied by two pins *h*, as shown in the plan view.

The box type of jig illustrated in Fig. 6 is for drilling the two end holes and the clamp-bolt hole in a small reverse lever. The lower view shows the jig in a position for drilling the clamp-bolt hole, while the upper view indicates its position when drilling the large and small holes in the ends.

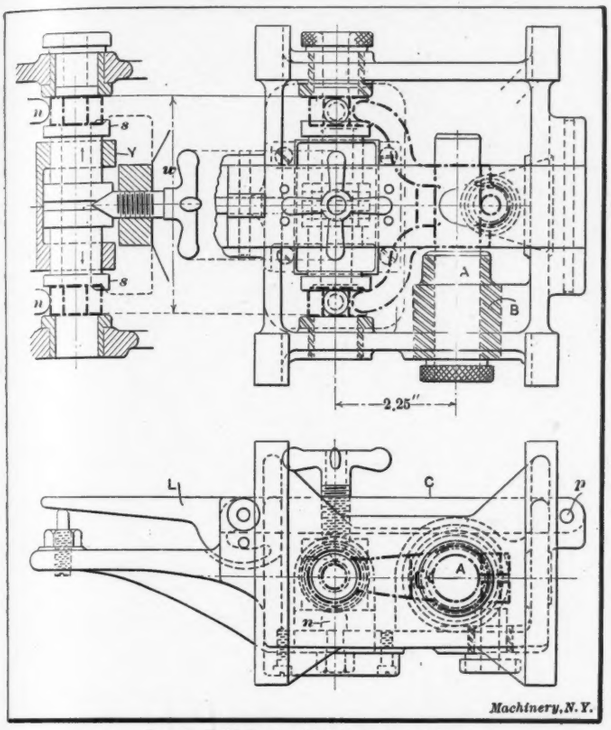


Fig. 7. Drill Jig for Clutch-shifting Yoke

The work is positioned by a stationary V-block *B*, at one end, and a V-lever *L* at the other. This lever is pivoted at *k* and has a flat spring *S* at the back which bears against the side of the jig. After the leaf or cover *C*—which swivels on pin *P*—is thrown back and the work is inserted, it is instantly located by the spring-actuated lever *L*. The top leaf is clamped by the eccentric- or cam-lever L_1 which rests, when in the closed position, on the adjustable stop-screw *a*. To insure a good bearing against the stationary V-block, there is a hand-screw *A* that is placed slightly above the center line as shown, so that the pressure of its spherical end against the round clamping-bolt boss will tend to force the work downward. All play between the lever *L* and the stud *k* on which it swivels, is eliminated by tightening the hand-screw *R*, this screw being set at an angle of 5 degrees which tends to draw the lever against the stud, thus holding it rigid.

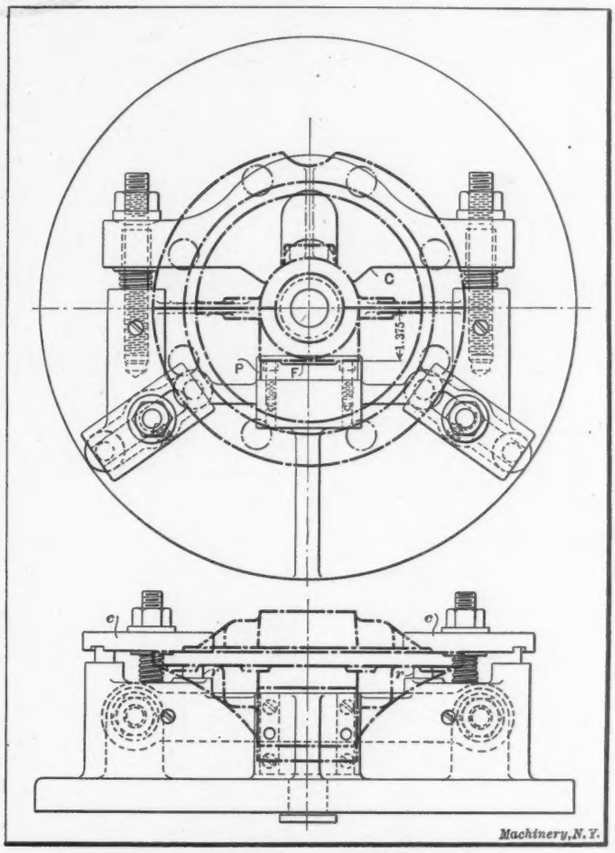


Fig. 8. Fixture for Chucking and Reaming 2-inch Hole in Bearing

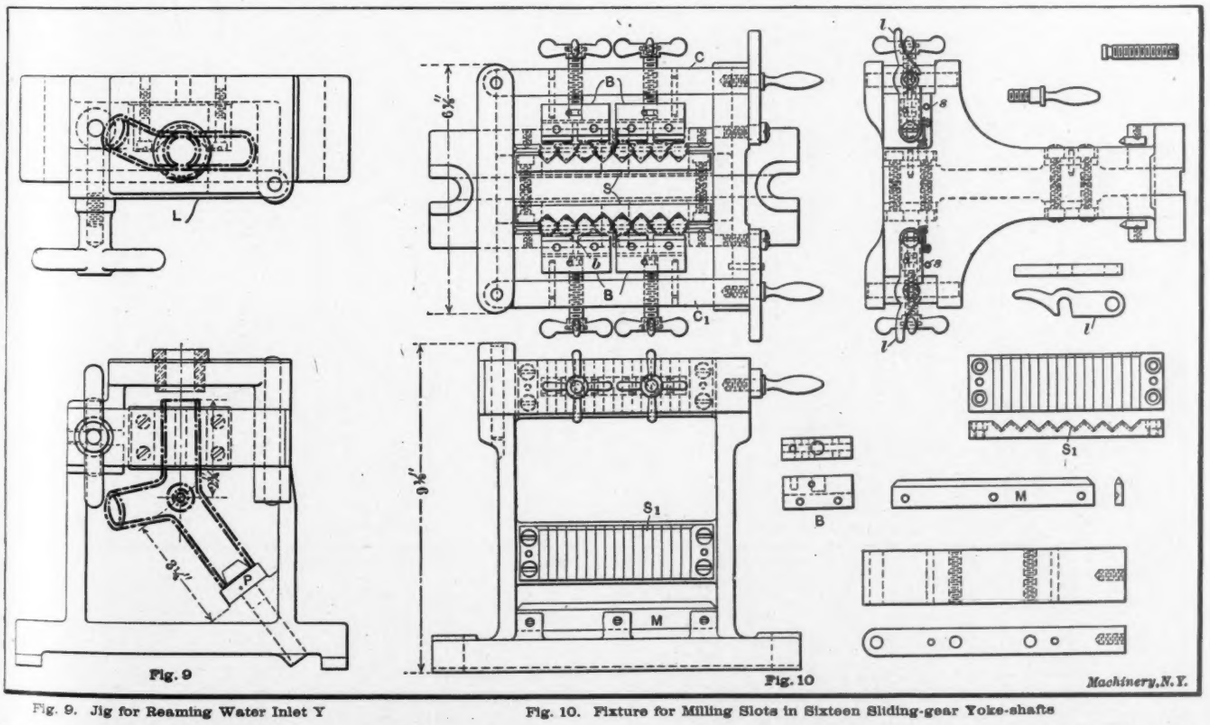


Fig. 9. Jig for Reaming Water Inlet Y

Fig. 10. Fixture for Milling Slots in Sixteen Sliding-gear Yoke-shafts

An interesting type of drill jig for a clutch-shifting yoke, is shown in Fig. 7. This jig is also of the box type, and it has a cover *C* that swivels on a pin *p* and is locked in the closed position by a cam-lever *L*. The work, shown in both

plan and elevation by the dot-and-dash lines, is located by a plug or arbor *A* (which passes through a previously finished hole in the hub) and also by the spherical pins *n*, which support the arms on each side. As the width *w* over the outside of the small bosses, had to be accurate, the clamping mechanism was designed not only to hold the work, but to prevent distortion from the strain of drilling. The construction of the two views. In this case it is necessary to have the hole 1.375 inch from the finished face *F*, so that the work is located by clamping it against a hardened pad or plate *P*. The large V-clamp *C* also gives an accurate setting laterally, while the vertical position is determined by the pins *r*. One of the noteworthy features of this fixture is the arrangement of the small clamps *c;* these are supported at the back by pins

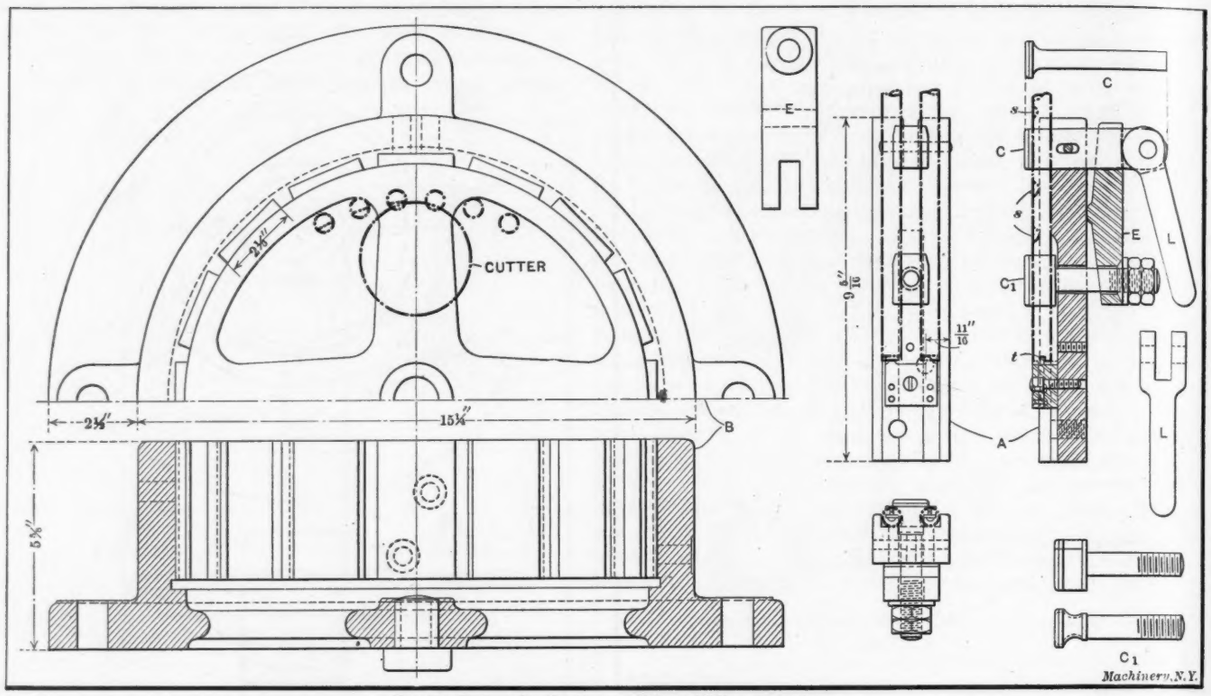


Fig. 11. Fixture for Continuous Rotary Milling Operation

this part of the jig is clearly shown in the plan view, in conjunction with the detail section at the left. The finished bosses of the yoke are a close fit between the accurately-finished inner faces of the drill bushings, and they are held rigidly against these bushings by the sleeves *s* which are forced outward by the conical-pointed screw shown, bearing against beveled surfaces on the inner flanges of the sleeves. which engage slots milled in the clamps on the under side so that the latter will not swivel out of place while being shifted back and forth. These small clamps as well as the large ones are equipped with springs which hold them against the binding nuts. This fixture is located centrally by a projecting boss in the base, as shown.

A jig for reaming an end of a water inlet Y is illustrated

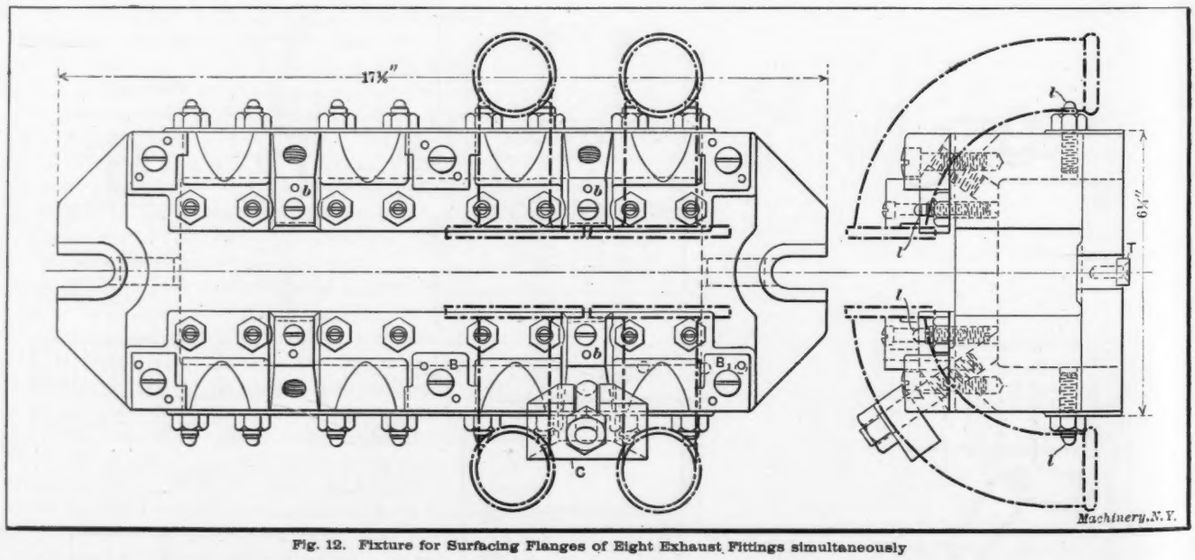


Fig. 12. Fixture for Surfacing Flanges of Eight Exhaust Fittings simultaneously

These clamping sleeves are guided by the yokes *Y* through which they pass. The outer ends of the sleeves which bear against the work, have flanges with conical extensions on the upper side that force the work downward against the pins *n*. The locating arbor *A* is hardened and ground and it has a good bearing in a large bushing *B* which is also hardened and ground.

The fixture shown in Fig. 8 is for chucking and reaming a 2-inch hole in a bearing, the shape of which is indicated in in Fig. 9. This inlet is located by a V-block at the top, and a conical boss *P* at the lower end. The clamping is effected by the leaf *L* which is tightened by the hand-nut shown. The design is simple and the work is easily inserted or removed. If the jig which the average draftsman would design for this part could also be shown, the reason for the illustration, Fig. 9, would doubtless be more apparent.

In Fig. 10 a fixture is shown which holds sixteen sliding-gear yoke-shafts while the ends are being slotted. As shown

by the plan and front elevation, these shafts are located by strips S and S_1, having V's as shown, and they are clamped by the four blocks B which are operated by hand-screws. Each of these blocks contains two pieces b which are mounted on pins inserted in the main block and are free to swivel. This construction insures a firm bearing on each of the sixteen shafts, even though some of them vary slightly in diameter. The fixture is loaded by inserting the shafts end-wise at the top. To prevent the ends of the shafts from catching on the tops of the lower strips S_1, the edges of the V's are beveled as shown. After the two rows of shafts have been slotted by a slitting saw operating on each side, they are quickly removed by swinging open the clamping bars C and C_1 which allows them to drop out of the fixture. As shown in the end elevation to the right, these bars are retained in the closed position by the thumb-latches l, which are held down, normally, by small spiral springs; small stop-pins s prevent the latches from swinging below the horizontal position.

After the shafts have been slotted as described in the preceding paragraph, they are placed in the fixture shown in Fig. 11, which is for milling the angular slots s shown in detail to the right. The main base B of this fixture has sixteen vertical slots as shown in the plan view, and each of these slots contains one of the clamping attachments A, which, in turn, holds two shafts as indicated by the dot-and-dash lines. The fixture rotates continually on a vertical machine, and the work is inserted and removed at the front, thus making the milling operation continuous. The relation of the work and cutter is indicated in the plan view. The interesting feature of this fixture is the clamping device with which each holder or attachment is equipped. This consists of two clamp-bolts C and C_1, which are operated by a cam-lever L that bears against an equalizing lever E engaging the lower clamping bolt, thus giving a uniform pressure at two points. With this arrangement, the two shafts in each holder are released or tightened by the operation of a single lever. The shafts are further prevented from turning by the slots, previously milled in their ends, which engage tongue-pieces t. The entire fixture is located centrally by a plug in the bottom of the base.

A fixture for holding eight exhaust fittings while the flange faces are being finished, is illustrated in Fig. 12. Each fitting is located by four spherical screws l and also by the oblong flanges which rest against the blocks b at the top. The clamping is effected by four slotted clamps C having beveled sides which force the fittings against the serrated faces of the blocks B and B_1. The fixture is aligned by the tongue-pieces T at each end. The spherical-headed screws l are slotted on the inside so that they can easily be adjusted when being set in the proper position, as determined by the casting itself. This fixture is a good example of the type which is efficient and at the same time inexpensive.

* * *

SOLVING A PRACTICAL PROBLEM BY SIMULTANEOUS EQUATIONS

By HOWARD TERHUNE*

The following problem came up in our drafting-room a short time ago, and as it was rather difficult to solve, the writer presents the solution herewith hoping that it may be of interest to others.

This problem was worked out in connection with a hydraulic brake of the geared type, as indicated in Fig. 1, the original form of which was as shown by the dotted lines. After testing, it was found that this type was not elastic enough, so it was necessary to add two small reservoirs, which were filled up after the valve was closed. The writer does not know the exact reason for the reservoirs being made as they were, or the location of them, but it is a good problem, however, and may be of interest to some one.

The problem was as follows: Given the diameter of the cylinders C and D, Fig. 1, as 7 inches, and their center distances equal to 7⅞ inches, equidistant from the center line of the large circle A, and the distance from the center line of the circles C and D to the top of the circle A as 6¼ inches; find the radius of the large circle.

As shown in Fig. 2, a line from the center F of the large circle A through the centers of either of the smaller circles will pass through the point of tangency of the two circles. Then we have two values for the radius of the large circle, R, as follows:

$$R = x + 6\tfrac{1}{4} \text{ inches} \quad (1)$$

$$R = y + 3\tfrac{1}{2} \text{ inches} \quad (2)$$

But in the triangle B, $x^2 = y^2 - \left(3\frac{15}{16}\right)^2$

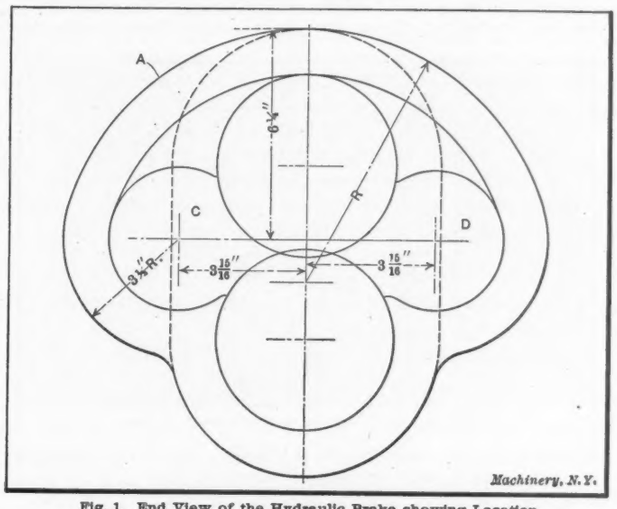


Fig. 1. End View of the Hydraulic Brake showing Location of the Cylinders

Substituting this in (1) we have:

$$R = \sqrt{y^2 - \left(3\frac{15}{16}\right)^2} + 6\tfrac{1}{4} \quad (3)$$

Subtracting (2) from (3) we have:

$$0 = \sqrt{y^2 - \left(3\frac{15}{16}\right)^2} - y + 2\tfrac{1}{4} \quad (4)$$

Then transposing and squaring we have:

$$y^2 - \left(3\frac{15}{16}\right)^2 = y^2 - 5\tfrac{1}{2}\,y + (2\tfrac{1}{4})^2 \quad (5)$$

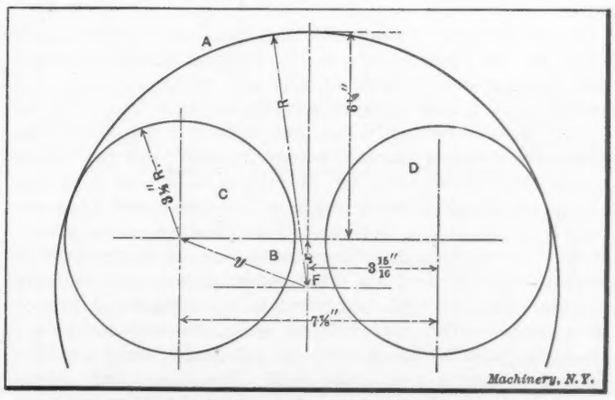


Fig. 2. Illustration showing the Location of the Cylinders C and D in Relation to the Large Circle

Collecting terms we get:

$$5\tfrac{1}{2}y = \left(3\frac{15}{16}\right)^2 + (2\tfrac{1}{4})^2 \quad (6)$$

in which $y = 4.194$. Then $R = 4.194 + 3.5 = 7.694$ inches.

* * *

Of the machinery imported into Brazil, the United States in 1909 supplied 27 per cent, while Great Britain supplied nearly 39 per cent and Germany nearly 18 per cent. The total value of the machinery imports from the United States were approximately $4,730,000.

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THE SYSTEMATIC SCRAP BOOK

By R. E. ASHLEY*

Since the appearance of the aritcle "A Systematic Scrap Book" in the November issue, the writer has received many inquiries from different parts of the country, regarding various details of the system used, and as lack of time forbade answering those inquiries as fully as the writer would wish to do, or at the length necessary to make a full and complete explanation, this second article is presented, in which these questions will be answered, and different phases of the system taken up in anticipation of the troublesome points which engineers may encounter in commencing a similar system.

In beginning a scrap book, perhaps the first perplexing question is that of dimensions—what size will be most con-

STEEL

Enamel for	4-26
Derusting of in concrete	4-38
Cement for gluing fabric to	7-21
Annealing	16-44
Bluing Iron or	3-7
Enamel Coating for pans of Iron or	5-93
To coat with copper 7-9,	4-47
Factors of safety of	10-12
Etching acid for	16-169
The electrical process of making	5-87

Fig. 1. File Card showing Convenient Method of Indexing

venient and best accommodate the scraps. This is a question that is rather difficult to answer in a general way, as each engineer must decide upon the size that will best care for the information which he gathers on his own particular line of work. The writer, however, finds a sheet 13 inches wide by 16 inches long a very convenient size for a scrap book such as is shown in Fig. 1 of the former article, and believes this size would answer the requirements of the majority of engineers. If a sheet much larger than this is used the book will be cumbersome, and inconvenient to use for reference purposes at the desk or drafting board, and will, in all probability, be too large to keep in a book-case or drawer. On the other hand if the sheet is too small the book will build up rapidly and become too bulky for convenience, and besides trouble will be experienced in keeping the book open, especially when the pages being referred to are near either cover.

As to the kind of binder to use, there are a great many styles on the market, but, in the writer's opinion, the best and cheapest one for general purposes, is the sectional post binder, with ⅜-inch posts, in sections one inch long with the bottom section riveted to the base. In this connection the writer recommends the top section threaded, and the use of countersunk thumb-nuts, for the thickness of the book can always be regulated to the length of the thread, and by screwing down the nuts a positive grip is obtained on the cover. With a key locking device, unless a very expensive style is used, trouble arises by the covers working loose and refusing to hold when the book has grown to a thickness of two or three inches. With regard to the style of cover, one can get stock covers in standard sizes from loose-leaf outfitters, but these are usually heavy and stiff. The writer had special covers made of black leather, which are flexible and much more convenient.

In place of the binders shown in Fig. 3 in the former article, one could use a "price book cover" which can be obtained at nearly any stationer's or dealer in office supplies. These come in different sizes, and an index and plain or cross-section paper can be secured for each size at any place where the covers are carried. There are several styles of these covers, the least expensive perhaps being the ring style which would probably answer in most cases.

The writer has been asked whether he would recommend the keeping of the "hand-book" in writing or by lettering. This is a point that depends upon the amount of time one could devote to it, though undoubtedly a typewriter would be quicker and more satisfactory where there are many notes to copy and but few sketches, drawings or diagrams. A note illustrated by sketches or drawings would have to be entered by hand, and in this case lettering would be preferable. So if one has the time and ability, the writer would say to put the work in by lettering, as this adds to the interest and individuality of the work, and tends to fix the matter in one's mind, making it easier and more valuable for reference.

The making of the index requires considerable thought, and it should be laid out to some extent on pieces of paper to determine the main and sub-headings necessary to best fulfill the requirements of one's particular business. The main headings should be general subjects, each of which is distinct from the other; and then, as stated in the former article, the number of sub-headings would depend upon the importance of the subject and the extent to which one would wish to facilitate the finding of any topic. Of course the greater the number of sub-headings, the smaller the number of cards one would have to look through in locating any subject, and hence time is saved. With any engineer there are a great many articles and references which would be seldom required, while other articles, touching more directly upon the work engaged in, would be referred to perhaps several times in a day, and the finding of such references would be facilitated by closer subdivisions of the subjects.

The size of the card for the index would depend to a great extent upon the completeness with which one wished to enter and describe the articles. The writer uses a standard 3 by 5 card and finds this size very satisfactory. In indexing it is well to enter the points touched upon in the article rather more fully than may at the time seem necessary when the whole text is fresh in the mind, for one is likely to abbreviate so much that, when looking up the matter later, he will find that doubt exists as to whether that particular article contains the information wanted, making it necessary to look up several articles before the one desired is found.

Fig. 1 shows a card and method of indexing. This particular card is for "steel" and is found under the sub-heading

KEY

1 Text Book - Mechanics of Materials - Merriman
2 Freehand and Perspective Drawing - Everett-Lawrence
3 Steel Mill Buildings - Ketchum
4 Steam Boilers - H. deB. Parsons
5 Hand Book of Calculations for Engineers - Hawkins
6 6x9 Machinery Data Sheets
7 16x13 Scrap Book

Fig. 2. File Card giving Key to the Assigned Numbers of the Article to be referred to

"Steel" of the subject "Materials." The color and its title show its position in the index, so that it can always be returned to its proper place. The figures at the right-hand side of the card give the book and page number. Because of the similarity of two or more articles it is often necessary to enter more of a description on the card than the illustration shows. As it is impossible to so subdivide every subject that each article could be entered under a proper sub-heading each subject has its alphabetical index for miscellaneous articles.

In the former article, reference was made to the number assigned to each book, volume of magazines or catalogue in which information that was indexed was to be found. The numbers begin with 1 and are consecutive. The key to the assigned numbers is given on several cards at the front of the index, one of which is shown in Fig. 2. The description consists of the book number, title and author, and the volume number if the book is one of a set.

* Address: 258 Sanford St., Muskegon, Mich.

MACHINE SHOP PRACTICE*

A VERTICAL BORING-MILL OPERATION

The turning of a flywheel, which is an operation described in the current Supplement, is a good example of the kind of work to which the vertical boring mill is adapted. The horizontal work-table makes it comparatively easy to adjust and clamp the casting, and this type of machine is also designed to take the heavy cuts required on work of this class.

A flywheel should preferably be machined on a double-headed mill so that one side and the periphery can be turned at the same time. A common method of holding a casting of this kind is indicated in Fig. 1. The rim is gripped by the chuck jaws *C* which, if practicable, should be placed on the inside, as shown, so as not to interfere with the movement of

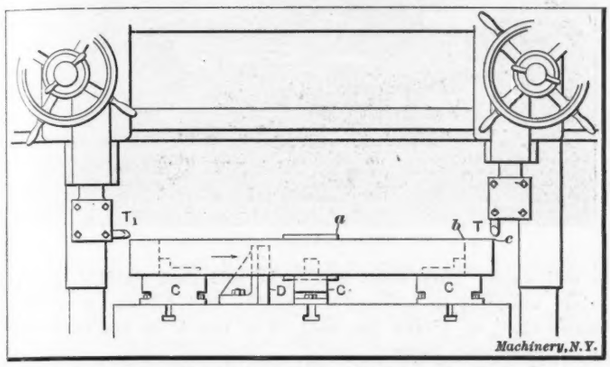


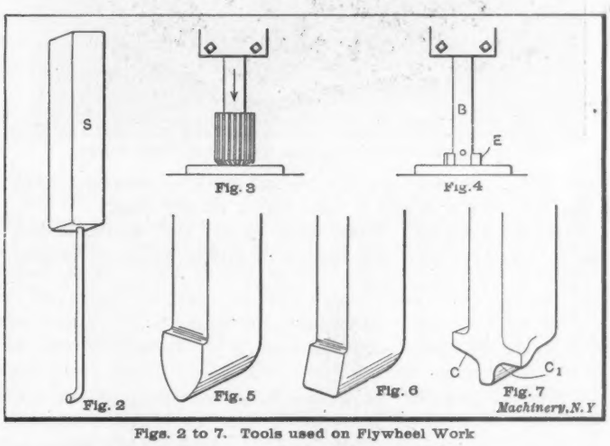
Fig. 1. Double-headed Boring Mill arranged for Turning a Flywheel

tool *T*. If the inside of the rim is so shaped that the jaws cannot get a good grip, it will, of course, be necessary to place them on the outside, which surface will then be machined after the casting is turned over; it is advisable, however, to finish the outside or periphery when the hole is bored, so that the hole and rim will be perfectly concentric. In addition to the chuck jaws, there should be a clamp placed across the spokes on each side of the wheel, and the casting should be further prevented from slipping in the chuck jaws by the use of two drivers *D* which, in this case, are stiff angle-irons, set against the spokes on opposite sides of the wheel. When a heavy cut is being taken, with the work revolving in the direction indicated by the arrow, the casting, owing to the circumferential pressure of the cut, will tend to shift around in the opposite direction; by means of the drivers *D*, however, such movement is resisted.

After the casting is clamped lightly, it should be set to run true. As the inside of the rim is usually left rough, the work should be set by this surface rather than by the outside, so that the rim, when finished, will be uniform in thickness. The tool or gage, illustrated in Fig. 2, will be found a great aid when truing up cylindrical work in the boring mill. It consists of a hard-wood shank *S* into which is inserted a piece of brass or copper wire (about No. 8 size) having the outer end bent as shown. When this gage is clamped in the toolpost, the wire, owing to its flexibility, is excellent for testing, as moving it too close to a surface which is not true, simply causes it to be bent backward. If the under side of the rim, because of unevenness, does not bear on all the jaws, packing should be inserted so that it rests solidly. It is well to test the rim with a surface gage to see that the sides are practically parallel with the table.

When taking the first or roughing cut, a tool similar in shape to the one illustrated in Fig. 5, should be used. Ordinarily one roughing and one finishing cut is sufficient. If the rim needs to be a certain width, about the same amount of metal should be removed from each side, unless bad spots, such as blow-holes, etc., make it necessary to take more from one side than the other. By placing that side of the work up which was uppermost when the casting was made, blow-holes and porous, sandy spots which are often found at the top, can be discovered while truing the first side. After tool *T* is started across the side, tool T_1 should be set in far enough to true the rim and be fed downward across the periphery, both tools operating at the same time. The tool for turning the periphery must, of course, be clamped in the toolpost with the cutting edge toward the back of the mill. When tool *T* has finished its cut, it should be used for roughing the hub. After the roughing cuts are taken, the tools are replaced by broad-nose finishing tools, similar to the one shown in Fig. 6. The feed should be increased for finishing so that each tool will have a movement, of say, ¼ or ⅜ inch per revolution of the work, and the cut should be deep enough to remove the marks made by the roughing tools. The cutting edge of tool *T* should be parallel, and that of tool T_1 at right angles to the table so that the finished surface will be smooth. After finishing cuts over the rim and hub have been taken, the corners *a*, *b* and *c* are usually rounded to give the work a more finished appearance, by the use of a tool shaped as shown in Fig. 7; this tool has two rounded cutting edges *C* and C_1, one being for the inner and the other for the outer corners.

The hole through the hub is next finished to size. The method of performing this operation will depend somewhat on the tools available. Ordinarily where flywheels are being machined in quantity, all holes should be finished to the same size by the use of a standard reamer; this should be fed slowly down through the hole as indicated in Fig. 3, after the hole has been previously bored slightly less than the size. In some shops, double-ended flat cutters *E*, Fig. 4, are used. These cutters are in roughing and finishing sizes and are inserted in a bar *B* held at the upper end by the ram, and in some instances guided by passing through a close-fitting bushing in the table. Evidently this cutter must be set central, as otherwise it will cut larger than its length. The position of the cutter may be tested by raising it as soon as the hole is started and inserting pieces of thin paper on each side; if when the cutter is returned to the hole, the paper strips on both sides are held fast, the position of the cutter is practically central. On interchangeable work where all holes are required to be of the same size, the use of a reamer of the "floating" shell type is preferable for finishing.



Figs. 2 to 7. Tools used on Flywheel Work

When the hole is finished, the work is turned over so that the lower side of the rim and hub can be faced and the corners rounded. If much flywheel work is being done, it is well to have a plug that fits the central hole in the table and the bore of the wheel, for setting the partly finished casting central when it is turned over. The chuck jaws are removed, and the work, which is located by the plug, may be clamped against parallels resting on the table. Care should be taken when facing the hub, to have it central with the rim, or in whatever relation is indicated on the drawing.

* * *

About 4500 vessels (or an average of between 12 and 13 a day) pass yearly through the Suez Canal. The average tonnage of the vessels is about 3600 tons. The length of the canal is about 100 miles, and the average time of passage is 17 hours. The largest vessel which ever passed through the canal is the 18,000-ton Hamburg-American liner *Cleveland*.

* With Shop Operation Sheet Supplement.

MACHINE TOOL DESIGN A LA COBHOUSE

These illustrations of a universal grinding machine built in Germany were reproduced from a foreign contemporary several months ago with the idea in mind of calling attention to its exceptional (!) features. Perhaps it is not far from the truth to say that our original intention was to "roast" it, but the hot weather came on to roast us and we relented—for the

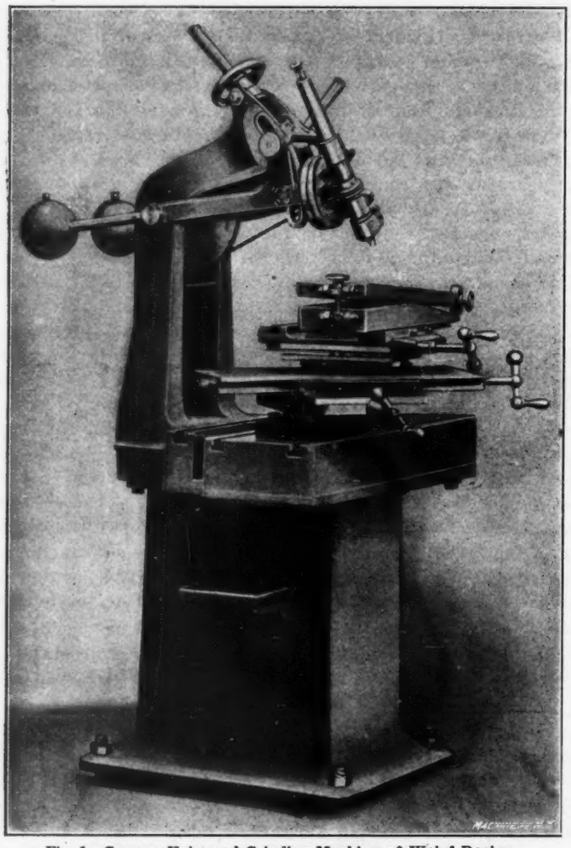


Fig. 1. German Universal Grinding Machine of Weird Design

time being. Summer quickly passed away as summers have a way of doing and still the job rested on our hands.

What could we do? What could we say that would do justice to this cob-house aggregation of slides—slides at angles, slides superimposed, slides thrown in for good measure, slides for goodness knows what! Pelion on Ossa! We gave up. Not for the world would we now say anything derogatory of this striking and liberal application of Maudslay's great principle. We would not point to overhanging slides so slender that the inexperienced might fear they would break off sheerly by their own weight. Nor would we preach a sermon on the folly of constructing precision machines with a multiplicity of joints and frail working parts between the cutter and the frame. People don't like to be criticised or told of the faults of their work; it tends to make them stubborn and set

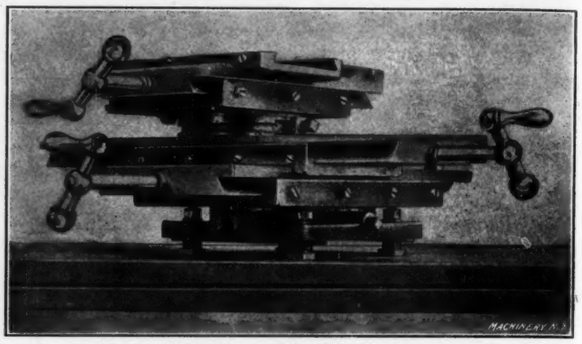


Fig. 3. Five Slides and Two Joints—Count 'em!

in evil ways. They don't like to be told that rigidity is the prime essential in successful machine tool design—everyone knows that, so what's the use? The rub is to get them to apply what they know.

Perhaps there are a few machine tool makers on this side of the salt pond who could spare a slide or two. Who knows?

* * *

An interurban railway in Pennsylvania has painted a narrow horizontal stripe extending along the sides and ends of the cars at a distance of 45 inches from the floor. The purpose of this line, according to the *Railway and Engineering Review*, is to afford a gage by which juvenile passengers may be measured. All who reach above the line will be expected to pay full fare; those who do not reach up to the line will be passed for half fare. The age limit as a means of determining whether a child will pay full or half fare has thus been abandoned for the height limit, which is really a more rational gage, as the cost of transportation depends upon the size and weight of the passenger. Besides, this method removes the temptation for breaking the ninth commandment.

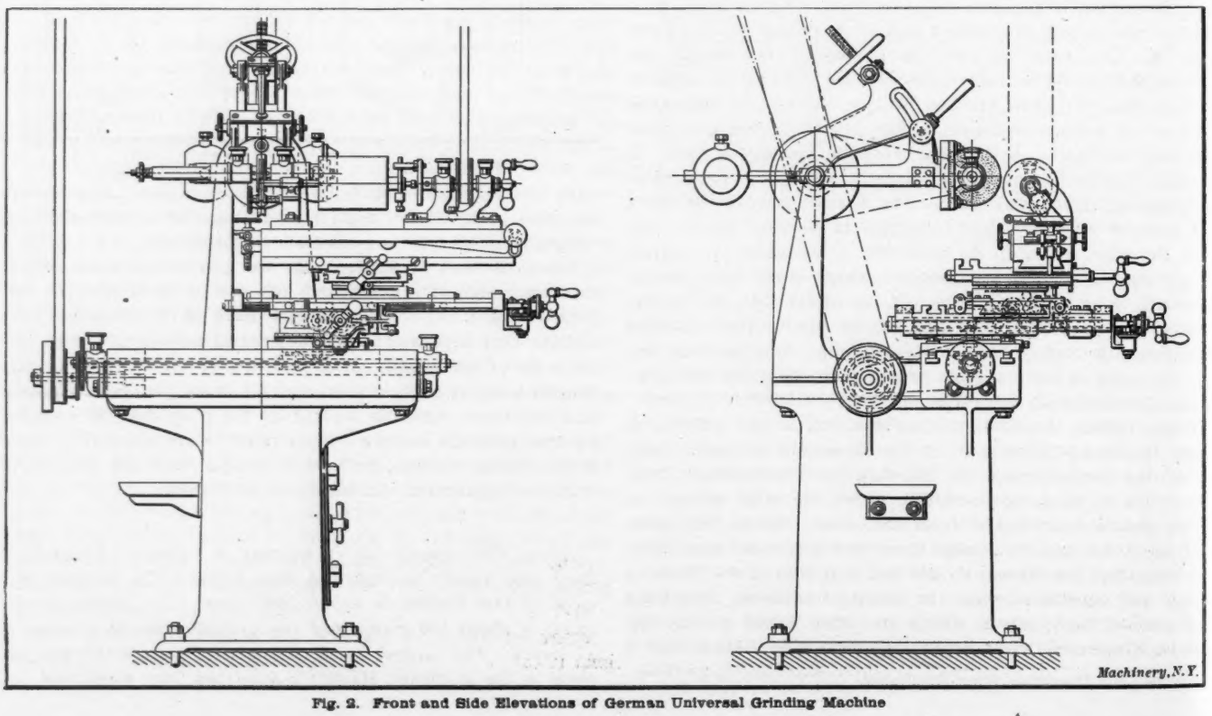


Fig. 2. Front and Side Elevations of German Universal Grinding Machine

TOOLMAKER'S FILES*

HISTORY OF THE DEVELOPMENT OF MANUFACTURE IN THE UNITED STATES

By E. P. REICHHELM†

The making of toolmaker's files, or "files of precision" as the Swiss call them, is practically an infant industry in the United States, whose effective competition with imported Swiss files did not begin until about six years ago, when a full line of this distinct class of files was first placed upon the market as a domestic product.

The development of this branch of the file industry was retarded by the difficulty of producing the great variety of shapes, cuts, and sizes to match the Swiss line consisting of about 2300 different files, the finer cuts, and accurate shapes of which required the modification of manufacturing methods in essential particulars, especially in the use of machinery.

About twenty-five years ago, the first attempt was made to produce "Swiss" files, in Paterson, N. J., a number of Swiss workmen having been brought over from Switzerland to teach us Swiss methods. These men, of course, received American wages which amounted to about as many dollars as they had received francs for the same work in Switzerland, and the tariff wall, high as it was, proved too low to cover the difference in labor cost, to say nothing of the higher cost of material.

Furthermore, it was discovered that these Swiss filemakers, transplanted to America, did not produce the standard quality of Swiss files; and not only were they disinclined to teach other men the tricks of the trade, but, removed from their accustomed environment, and the direction of their former employers, their skill deteriorated, while their demands for higher wages still further discouraged the enterprise.

Several subsequent attempts to make "files of precision" resulted in producing only a limited assortment of inferior files, so that toolmakers, gunsmiths, makers of fine instruments, jewelers, silversmiths, die sinkers, and other mechanics using fine files in shaping and finishing, naturally came to believe that none but the genuine imported Swiss files would do.

But that Swiss files *could* be made in America, seemed a self-evident proposition to the writer. As a builder of gas furnaces, he had occasion to visit file factories with a view to equipping them with gas furnaces, and from observation of their practice, he was convinced that, with proper modifications in methods and machinery, the imported files could be duplicated, and even improved upon, especially in temper.

Practical mechanics will agree that a mere imitation of other people's methods of work will never produce first-class results; and that to improve the means of production in any line, it is not only necessary to be posted with regard to the best practice in that particular line, but to find out how analagous work is done in other lines, for only in this way can settled prejudice be overcome, and the daily practice lifted out of old ruts. The writer therefore looked at the file industry as carried on under his observation, with different eyes than those of the filemakers themselves; and, convinced that Swiss files could be made in America, at a profit, was induced to try it.

The enterprise was started in January, 1900, in a small but well-equipped factory, at Elizabethport, N. J. At first, the Swiss files made there cost twice as much as they could be sold for, and it took five years to improve manufacturing methods sufficiently to make many shapes and sizes at a low enough cost to leave a small profit.

In 1906, however, the factory yielded a fair return on the capital invested, and plans for its enlargement were made, resulting in the present factory, covering an area of about thirteen city lots. The equipment of the enlarged factory resulted from the experience in the small one, and not from the imitation of either foreign or domestic file-making practice.

The output of this larger factory, completed in May, 1907, is now somewhat restricted by the difficulty of training a sufficient force, the men with experience in other file shops having to be taught to do their work in a different manner than that to which they have been accustomed, while the training of apprentices, new to the trade, is hindered by the absence of an equitable law governing apprenticeship. It is easy enough to hire hands if the wages offered are high, but to get a boy to learn the trade from the bottom up, and be satisfied with small wages until he has mastered the trade, is a different matter; so the working force can be increased only gradually and at considerable loss, represented in spoiled work.

Toolmaker's files are in a class by themselves, differing as much from the common American files as do silk from woolen fabrics; and considering the accuracy of the workmanship, and the high-grade steel out of which they are made, the selling price must be considered very moderate indeed. Owing to their keen cut, correct shape, and the superior steel used in making them, they are frequently preferred to cheaper files, even for uses for which they are not intended, their greater durability compensating for the difference in cost. The marked differences between the common American files, and the toolmaker's files, are the following:

1. *With regard to Cut:* The ordinary American files are made in five cuts, namely, rough, bastard, 2nd-cut, smooth, and super-smooth, while toolmaker's files are made in twelve cuts, numbered respectively from 000 to 8, the cut No. 3 in this line being as fine as the super-smooth cut of the common file.
2. *In Shape:* The toolmaker's file is distinguished by its sharp outline, teeth covering extremes of points and edges.
3. *In Size:* The toolmaker's files never exceed 12 inches length in any shape, and in width or thickness are more slender than the common files, and somewhat lighter.

One of the reasons for the present superiority of the American over the imported Swiss "files of precision," is the heat treatment of the American toolmaker's files, which, in the processes of forging, annealing, and tempering, is automatically regulated. This is done by means of a heat controller, invented by Mr. George Machlet, Jr., of Elizabeth, N. J., which keeps the temperature of annealing and hardening furnaces constantly within 10 degrees of a standard heat to which the heat controller is set, thus producing a uniformity of temper never before obtained in manufacturing a similar product.

* * *

NEW BUILDINGS FOR THE UNIVERSITY OF CINCINNATI

One of the finest mechanical and engineering buildings in the West is being erected for the University of Cincinnati, at Cincinnati. The building itself is of concrete, 135 by 260 feet, three stores high over the entire area and four stories high at the middle section. It will accommodate 500 students at one time, which means 1000 cooperative students working on the plan carried out at the school, and is to cost $250,000. An additional $50,000 is also to be spent for equipment. The main walls and part of the floors are already in place, and it is expected that it will be ready for occupancy in time for the fall term of 1911.

An important feature of the building is the mechanical laboratory, 40 by 220 feet, which will contain machinery and instruments for all sorts of mechanical engineering tests and practice. There are six well-lighted rooms for students of drawing, capable of holding 40 each or 240 in all. Numerous points of unusual interest have been incorporated in the design and equipment of the building which will be gone over more thoroughly when the building is nearer completion. One point, however, that will be mentioned, is the fact that the class lecture rooms are so arranged that if a professor is instructing his class in machine design or work, a small shaper, lathe, drill-press or whatever it may happen to be, can be taken directly off the shop floor and set in the lecture room close to his desk, where it may be shown dismantled or used in any way he sees fit. This one feature alone is of unusual importance and the method by which it is actually done will be fully illustrated later.

Besides the building just described, a $150,000 power house and $100,000 gymnasium are in course of construction and will be finished about the same time.

* For articles on the manufacture of "files of precision" see "Making Swiss Files in America", September and October, 1907.

† President American Swiss File & Tool Co., 24 John St., New York.

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY.

PUNCH AND DIE FOR BLANKING HEXAGON NUTS

The accompanying illustrations show a very interesting punch and die for blanking out seven hexagon nuts at one stroke of the press which makes practically no scrap. All the scrap that is made is half a nut on the first row on the starting of each sheet, and also a narrow strip and small V-portion removed from the sides. This punch and die with proper care will cut out an average of 250,000 nuts in a day. This the writer considers a very good production.

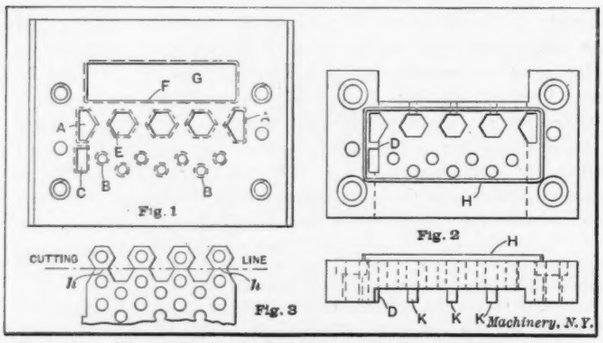


Fig. 1. Plan View of Die-block showing how Punches are laid out to save Stock. Fig. 2. Plan and Elevation of Stripper-plate showing Stops for Gaging the Stock to Length. Fig. 3. Condition of the Sheet after the Third Stroke of the Press

A plan of the die-block is shown in Fig. 1, where it can be seen how the holes are laid out so as to waste practically no stock. The two end holes *A* are made so that they cut V-notches in each side of the strip which produces one side of two nuts on each side of the strip as shown in Fig. 3. The seven holes *B* in the die are used for blanking the holes in the nuts. A punch working in the hole *C* in the die cuts a narrow strip from the sheet, thus forming a ledge on it, which is used for a guide in allowing the stock to be fed in the required amount for each blanking. A corresponding ledge *D* is formed on the stripper-plate shown in Fig. 2, which acts as the stop in starting the sheet. After the first row of three holes has been blanked, the projections *K* on the stripper-plate act as stops. By having the stock located in this manner it is not necessary to have pilots in the punches.

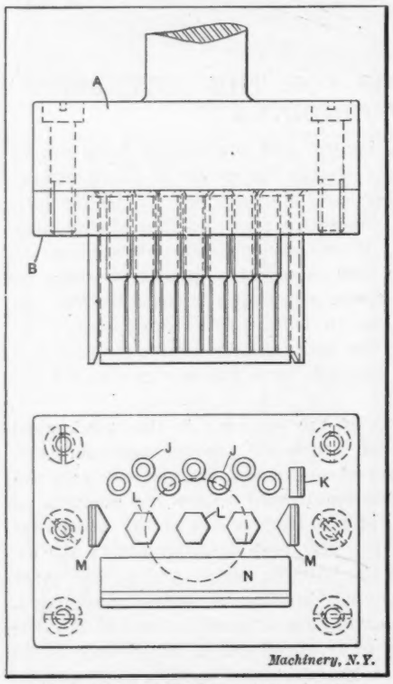


Fig. 4. Plan and Elevation of Punch-holder and Punches

The three hexagon holes *E* in the die are used for cutting out three nuts. The fourth row of nuts is cut off at the edge *F* of the hole *G* in the die, it only being necessary for the small webs *h* to be severed in this operation (see Fig. 3). As the punches are made a good fit in the stripper-plate, it is necessary to have them well lubricated, so a narrow strip of sheet steel *H* is bent to the shape shown, and soldered onto the top of the stripper-plate, thus preventing the oil from spreading, and confining it to the punches.

A plan and elevation of the punches and punch-holder are shown in Fig. 4. Here *J* are the piercing punches for the holes in the nuts, *K* is the punch which is used for shaving a narrow strip from the blank, forming a ledge on it, which is used in stopping the stock to the desired length. The three hexagon punches *L* are used for blanking out three nuts, and the punches *M* are used for forming one side of the fourth row of nuts, while *N* is the punch which is used for shearing the four nuts from the sheet. The punches are driven into the punch-plate *B*, as shown, and are riveted over to prevent them from pulling out. The punch-holder *A* is made of cast iron and the punch-plate is held to it by six fillister-head screws. As the punches are well supported in the stripper-plate this method of holding them in the punch-plate is effective enough for this class of work.

CHARLES PABESHUTZ

Milwaukee, Wis.

TURNING RUBBER WASHERS

Recently the writer had occasion to turn down the outside diameter of some rubber packing washers, such as are used for garden hose, hydrants and also sometimes around the engine-room. Some difficulty was first encountered in turning these washers as, being decidedly soft, they would not stand up to the tool, especially when a heavy cut was taken. After having used a number of methods the following was adopted and proved satisfactory.

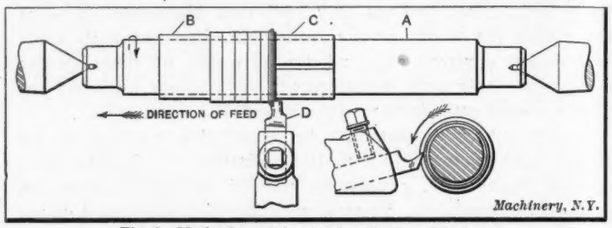


Fig. 1. Method used in Turning Rubber Washers

An ordinary arbor *A*, which was a good fit for the inside diameter of the washers, was used, and a sleeve *B* pressed onto it. The washers were placed on this arbor five at a time, and a piece of sheet copper 1/16 inch thick was bent around to the shape of the arbor, leaving an open space of about 1/16 inch. This sleeve *C* was then removed and squeezed in, so that it was made a tight fit for the arbor, and was then placed tight up against the washers as shown in Fig. 1. It might be well to mention that the pressure of the sleeve should not be too great, as it will tend to bulge out the washers. After the washers were put on the arbor and held with the sleeve *C*, the arbor was put on the centers of the lathe as shown, and a tool *D* made from high-speed steel, ground to the shape shown, was made. This tool was ground with considerable top rake, and also set at an angle with the horizontal center line. The action of this turning tool is clearly shown in the illustration, and the results of the turning are shown in Fig. 2. Here it can clearly be seen that it is not a chip that is

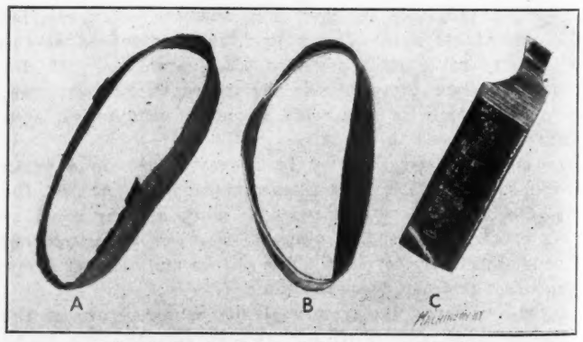


Fig. 2. Turning Tool and Rings removed by it

taken off, but a ring. The first ring removed is shown at *A*, and the second one is shown at *B*. A clearer view of the turning tool is shown at *C*.

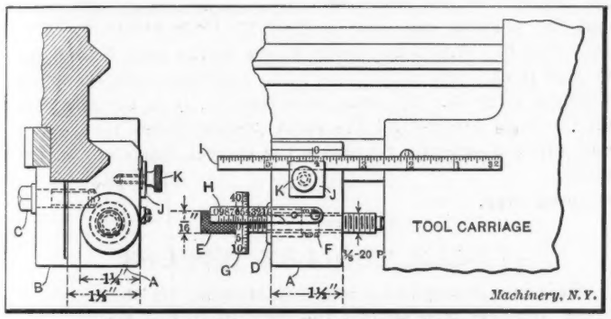
The speed used in turning was from 125 to 130 surface feet per minute, and the feed was not greater than from 0.010 to 0.015 inch per revolution. If a greater feed than this were used, the tool would not cut nearly so well, and would make a more ragged job. It was also found that five washers were the most that could be turned at one time, and give entire satisfaction. If more washers than this were put on the arbor they would crowd up on each other and would make an uneven job. Forty-eight washers were turned without regrinding the tool.

FRANK LANG

Covington, Ky.

A MICROMETER STOP FOR THE LATHE CARRIAGE

The accompanying illustration shows a stop which the writer believes will be of interest to readers of MACHINERY. It consists of a frame *A*, which is held by a block *B* and a cap-screw *C* to the ways of the lathe. This frame can be conveniently made from 1½- by 2- by 1½-inch machine steel, and is counterbored to receive the tension bushing *D*. The micrometer screw *E* is tapped into the rear portion of the block *A*, and backlash is prevented in the screw by means of the bushing *D*, which is also tapped to fit the screw, and held out from the frame *A* by means of a tension spring *F*. The



A Convenient Micrometer Stop for the Lathe Carriage

threaded portion of the micrometer screw *E* is made ⅜ inch in diameter with a 20-pitch thread, so that for every revolution of the screw it will advance 0.050 inch. The graduated portion *G* of this screw has, therefore, fifty divisions, each division being equal to 0.001 inch. On the top of the bracket is fastened a scale *H*, which is graduated for one inch, this space being divided into hundredths of an inch. It, therefore, can be seen that readings to 0.001 inch can easily be obtained.

An additional scale *I* is fastened to the frame *A* by the clamp *J* and thumb-screw *K*. This scale can be used when distances varying more than 1 inch in length are required. This scale is a 6-inch narrow scale and can be set separate or in conjunction with the micrometer screw. Two zero marks are provided, one on the frame *A* and one on the carriage of the lathe, either one of which can be used as desired.

The writer has found this attachment very useful for facing work and also for boring holes, as the depth of the hole can be readily measured or bored by means of it. The attachment could also be made without the tension bushing *D*, if desired, but as the screw wears, of course there would be a considerable amount of backlash, and it is therefore desirable to have this tension bushing to prevent it. The scale *H* should be made very carefully and can be held by a screw and dowel pin, as shown.

A. J. PETERSEN

Greenfield, Mass.

A SYSTEMATIC SCRAP-BOOK

In the November number of MACHINERY R. E. Ashley gives a description of an excellent plan for filing and preserving in a systematic manner articles of value which must be referred to frequently. In the article mentioned the writer lays stress on the fact that the most important and difficult feature of such a plan is the compiling of a thorough index system. For some time past the writer has been saving issues of MACHINERY containing articles on subjects not generally treated in other publications or text-books, and which are of great value to him in his everyday work. As the majority of readers know, it is a laborious task to keep up a card index, as each article has to be recorded and the card put in its proper place.

Most of the subjects which are of special value to the writer are jigs, fixtures, screw machine tools, etc. To keep the articles dealing with the above subjects in a systematic manner, a loose leaf binder was devised. This binder holds the various articles in such a manner that they can be conveniently located on short notice without the use of a card index system.

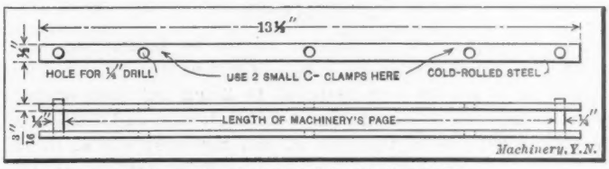


Fig. 1. Jig used for Drilling Binding Holes

After reading each issue of MACHINERY, the contents are filed in a loose leaf post binder, which is the size of a page. This is done by drilling holes to fit the three posts of the binder by means of the jig shown in Fig. 1. By drilling the holes in the magazine before the binding staples are removed, a much better and neater job is accomplished than when a quantity of loose sheets are drilled.

After drilling the holes, the advertising pages are removed, and the reading matter carefully separated. The latter is then collected and put in a binder with the different subjects separated by guide sheets such as shown in Fig. 2. These are made of stiff manilla paper and are prepared with projecting tabs on which are printed the general title of the articles filed under them. The articles are classified, such as drill jigs, gages, milling fixtures, planer tools, screw machine tools,

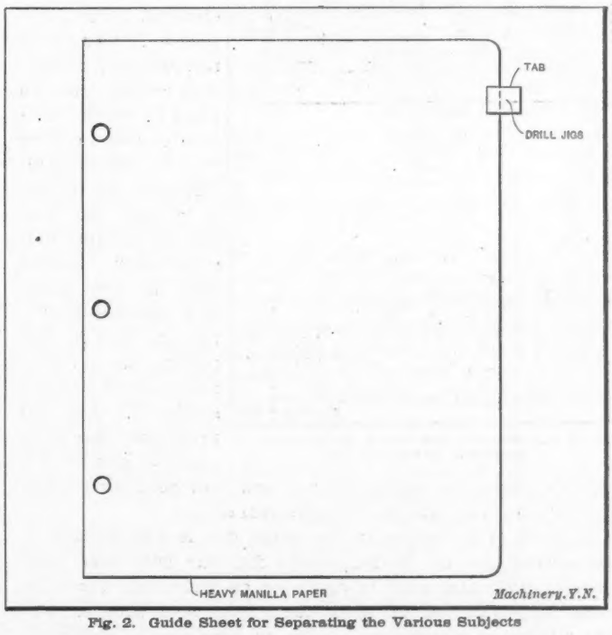


Fig. 2. Guide Sheet for Separating the Various Subjects

blanking dies, bending dies, etc. About fifty of these guide sheets are employed, and the pages containing articles on the various subjects are placed under their respective guides. In case there is a page containing articles on two or more subjects, the page is cut up and each piece is put in its proper place by being pasted to a blank page under the correct heading.

The above plan possesses several advantages, one of which is that it eliminates all elaborate and laborious index systems, for after the guide sheets are put in place it is an easy matter to insert any additional pages under the correct guide, and no further trouble is necessary. Another advantage is that

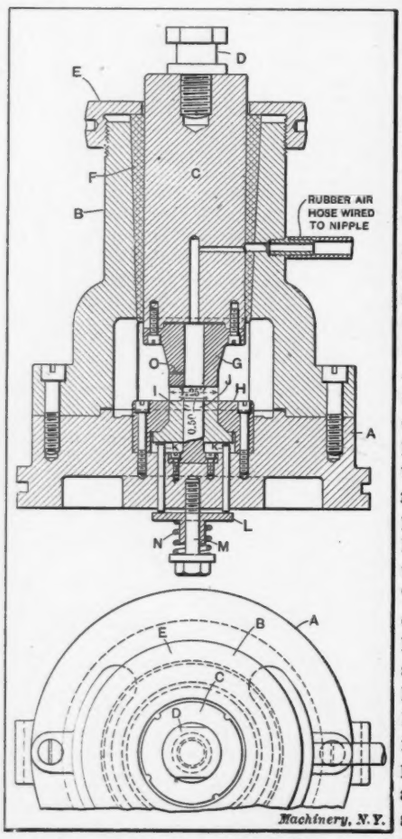
the binder can be taken away from the office and any particular reference looked up without either carrying a tray of index cards along or returning to the office to look through them.

It would appear to some that this system would require a longer time to find what you are looking for than it would by the card index system, but this is not the case, as it is only necessary to look at the tabs to find the heading under which the subject is located. If a sufficient number of these guide sheets are used and the space sub-divided as much as possible, there will not be a very large number of sheets under one guide.

DESIGNER

SUB-PRESS DIE FOR BLANKING THIN WASHERS

The accompanying illustration shows an interesting sub-press die, which embodies some new features in its construction. This die was designed to blank out thin copper washers 1¼-inch outside diameter, 1/2-inch hole, and 0.025-inch thick. It consists of the base *A*, and the sub-press *B*, these being of the usual construction, as are also the plunger *C*, button *D*, cap *E*, and the babbitting *F*. The piston *C* carries the upper die *G*, which is screwed and doweled to it. The base *A* accommodates the lower die *H*, stripper *I*, and punch *J*, for the hole. The punch *J* is held to the base *A* by screws as shown, and is also doweled. The push-pins *K* extend through base *A*, their ends resting upon the plate *L*, which has a hole drilled in it to receive the stud *M*. This stud is threaded at one end and has an integral nut-and-washer shaped head at the other. It is screwed tightly into the base *A*, supporting the plate *L* and compression spring *N*. This arrangement has been found to give a more uniform thrust on the push-pins than was obtainable when each pin was operated by an individual spring.



A Sub-press Die from which the Scrap is ejected by Compressed Air

In place of a shedder in the upper die, it was decided to use compressed air in the design for this particular case. Several other dies were in operation on practically the same class of work, and in these the complicated shedder was not altogether satisfactory, owing to breakage of push-pins, springs, etc. The piston *C* has a 1/4-inch hole drilled in its lower end, and a 1/8-inch hole drilled in from the side of the piston, which meets the central hole. This 1/8-inch hole registers with another 1/4-inch hole in the babbitting and sub-press casting, when the piston is at the top of its stroke. The hole in the casting is threaded, a brass nipple is screwed into it, and a rubber air hose is wired fast to the nipple at one end, and to a convenient air main at the other. It will, therefore, be seen that when the piston is at the bottom of its stroke, the air is cut off, and as it rises to the upper end, the air rushes in as the holes come into register, the air pressure forcing the scrap out of the hole in the die *G*.

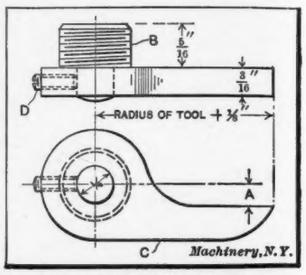
In order to relieve the air which is compressed in the hole in the die *G* during the blanking operation, a small hole *O* is drilled in *G* before it is hardened. This allows free working of the dies and at the same time does not interfere with the removal of the scrap. The sub-press complete is used in any power-press in the ordinary manner, except that the table of the press must have a hole in it large enough to clear the push-pin mechanism.

F. B.

TEMPLET USED IN GRINDING CIRCULAR FORMING TOOLS FOR SCREW MACHINES

The articles published in MACHINERY from time to time on automatic screw machine practice have been of particular interest to me, as I am engaged in making tools for automatic screw machines.

Having difficulty in grinding tools of varying diameters so that their diameters would be correctly transferred to the piece when cut below the center, I devised the gage shown in the accompanying illustration. This gage was made in three different sizes to fit the circular tools for the Nos. 00, 0 and 2 Brown & Sharpe automatic screw machines, respectively. The dimension *A* on the templet is made to suit the various tools, as is also plug *B*. This plug rotates freely in the gage *C*, but can be held in any desired position when necessary with the small headless screw *D*. By using this templet, it is obvious that all the tools are ground the same amount below the center, and will consequently reproduce the correct diameters on the work.



Templet used in Grinding Circular Tools the Correct Distance below the Center

F. W. RANDALL

New Haven, Conn.

I-BEAM TROLLEY DESIGNS

There is a strong and unmerited prejudice in the minds of many practical men against the form of trolley which is designed to run on the lower flanges of an I-beam, the reason given being that it "runs hard." An examination of some of the designs used reveals abundant reason why they should "run hard." Fig. 1 shows a design which, apart from its somewhat flimsy construction and consequent tendency to spring, has two marked defects which mar its efficiency. The first and most conspicuous defect is that of having cone-wheels

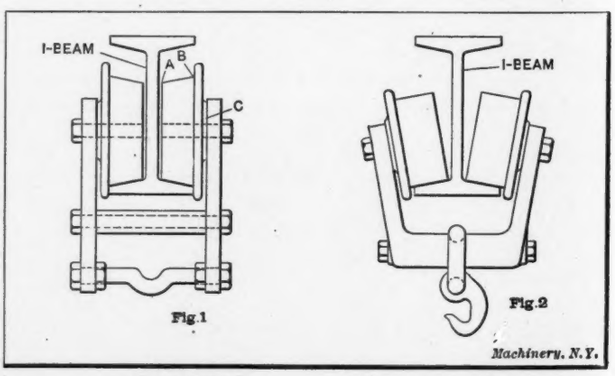


Fig. 1. Objectionable Design for I-Beam Trolleys

Fig. 2. Commendable Design for I-Beam Trolleys

running in a straight line, whereas the natural tendency of a cone is to roll in a circular path. In other words, a point on the larger diameter of the wheel moves say 24 inches per revolution, whereas a point on the smaller end of the wheel would only traverse say 22 inches per revolution, thus leaving a discrepancy of two inches, to be made up by sliding or scraping at every turn of the wheel. This discrepancy, of course, varies as the difference between the smaller and the larger circumference *A* and *B* of the wheel.

The second objection to this design of I-beam trolley is

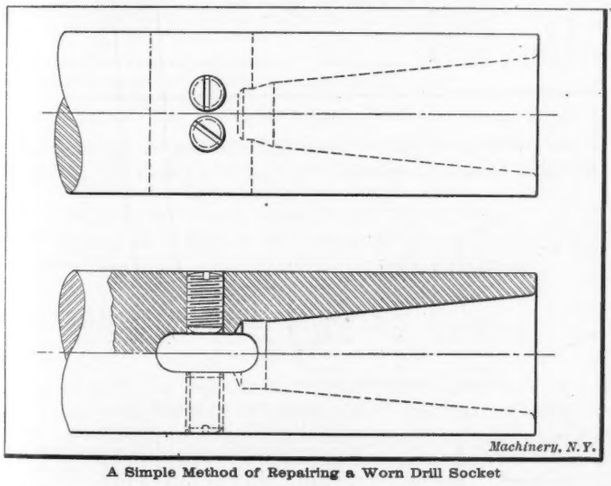
that the axes of the rollers are at an angle with the roller path, and hence considerable setting up or wedging action is the result which tends to push both wheels apart, thus causing unnecessary friction and a consequent wear between the hub *C* of the wheel and the frame. Both of these defects may be obviated, and a smooth-running trolley obtained by using wheels with a straight face and tilting their axes to the same angle as the face of the I-beam flange on which they run. A trolley of this description is shown in Fig. 2. Here, as can be seen, the axes of the rollers are in a horizontal position with the flange on the I-beam, thus allowing them to rotate freely without undue friction or wear. The wheels for this design of trolley should be as large in diameter as conditions will permit. S. M. RANSOME

Cleveland, Ohio.

[The design of I-beam trolley shown in Fig. 2 of course is not new, nor is it patented. The superiority of the design as compared with that of Fig. 1 is so obvious that it is a matter of surprise to find the latter in use but it is—to the discredit of the designer. It was described by Henry R. Towne in his "Treatise on Cranes," published in 1883. The flanges as shown on the pulleys are unnecessary.—EDITOR.]

METHOD OF REPAIRING A DRILL SOCKET

The mechanical journals are full of advertisements of cures for twisted drill tangs; but they do not say what you could do when the trouble is not with the tang, but with the spindle or drill socket itself, as is sometimes the case owing to careless handling. It frequently happens that the flats in a drill socket are often bruised or worn away by imperfect drill tangs, which causes considerable trouble. The accompanying illustration shows a very simple method of overcoming this difficulty, and



A Simple Method of Repairing a Worn Drill Socket

is as follows: The drill socket is tapped out for four tool-steel headless screws which are located as close together as possible. These screws are hardened and will last a considerable time. When broken or worn they can easily be removed and replaced with new ones. JOHN E. COOK

Birmingham, Ala.

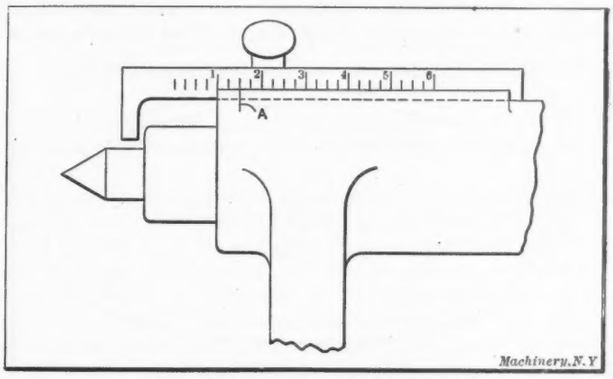
DEPTH GAGE FOR TAILSTOCK DRILLING

In the July number of MACHINERY Fred Horner suggests the use of a rubber band on the tailstock spindle for gaging the depth of holes when drilling in the lathe. This is a good device and is certainly easily accomplished and inexpensive, but it necessitates frequent measuring between the band and the tailstock to ascertain the depth. However, it is better than disfiguring the spindle with a confusion of scriber marks, which usually lead to errors.

A piece of chalk (preferably colored) having a sharp edge, obviates the difficulty which results from the too frequent use of the scriber, but the line made is not distinct. A string coated or saturated with red lead, and wrapped around the spindle close to the end of the tailstock makes a very good mark.

If much drilling is to be done and the tailstock spindle has no provision for gaging the depth, it is a very simple matter for a machinist to graduate the spindle. In the absence of a milling machine, the spacing may be accomplished to a certain degree of accuracy by placing the spindle on the centers of a lathe, and making the graduations with a suitable marking tool held in the toolpost. To do this, the carriage is moved by turning a gear keyed to the end of the lead-screw. For example, if the lead-screw is 1/4-inch lead, 1/16 of a revolution of the gear will move the carriage 1/64 inch; one-eighth of a revolution will give divisions 1/32 inch apart, etc. The gear can have sixteen teeth or any multiple of this number, such as 32, 48, 64, etc.

It would require but little time and ingenuity to make a simple locking device so that the divisions of this gear could be easily obtained. This locking device should fit approximately in a tooth space, and should slide in some sort of planed guide clamped to the headstock or the bed of the lathe.



A Convenient Stop-gage for Tailstock Drilling

It will be understood, of course, that this locking pin or wedge is to hold the gear (which is, of course, disengaged from the other change gears) while the lathe carrying the tailstock spindle is being turned by hand a fraction of a revolution. For each line required, the carriage is moved the proper distance, the locking-pin forced into a tooth space in the gear, the marking tool pressed lightly against the spindle by means of the cross-feed screw, and the lathe moved by hand through a small arc, thus making the graduations on the spindle. The locking pin is then disconnected from the gear in order to move it another space.

If the locking device is considered too expensive, a fixed pointer or finger may be used which can be brought into position against the face of the tooth, and thus gage the distance that the gear is moved for each graduation made on the spindle. The lines on the spindle should be of different lengths, so as to clearly distinguish the fine from the coarse divisions, and one or more limiting lines should be made lengthwise on the spindle to indicate the finishing points of the division lines.

A method which is better than a graduated spindle is a small stop-gage adjustably secured to the tailstock, as shown in the accompanying illustration. This stop-gage when set for the required depth, will stop the feed of the drill without any watching; therefore it is more convenient than the graduated spindle. If instead of a fixed zero line as shown at *A*, an adjustable finger were used, the device would be still more convenient. The writer has never known of a stop-gage being used on the tailstock of a lathe, but the idea occurred to him while reading Mr. Horner's article. W. S. LEONARD

Atlanta, Ga.

CUTTING THREADS HAVING FRACTIONAL PITCHES

It is not often that one is called upon to cut a thread having a fractional pitch, but we had to cut sixteen and one-third threads to the inch. This was accomplished in the following manner: A lathe was fitted up with a taper-turning attachment and the tailstock set over; then the taper attachment was set to correspond with it, so that the tool would cut evenly

all the way along the work. The thread was then cut as usual, the tool being set by the face of the tap. A thread cut in this manner would be slightly greater in pitch than the gears ordinarily would give if the tailstock had not been set over and a taper attachment used. It was necessary to take three or four trial cuts, but by setting the tailstock over nearly to the limit, it was accomplished successfully.

Seneca Falls, N. Y. WILLIAM FUESS

[A similar method, but illustrated, is given in MACHINERY'S reference series No. 32 for cutting taps long in lead. This was taken from the April, 1899, issue of MACHINERY.—EDITOR.]

A DANGEROUS DRIP-CUP

We hear so much talk about having to dodge airships these days that the writer thinks it would be appropriate to speak about dodging oil drip-cups, which the machinist sometimes has to do. Although there are a large number of first-class types of drip-cups on hangers, one objectionable type which is commonly used is shown in Fig. 1. This drip-cup has a

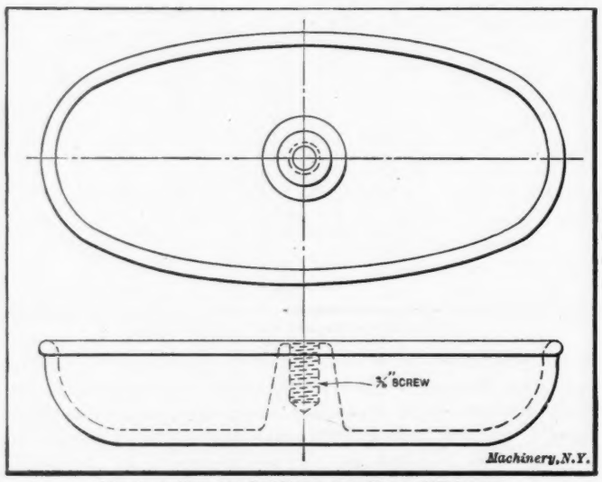


Fig. 1. A Common but Dangerous Type of Drip-cup

hub cast inside of it, which is tapped to fit a ⅝-inch bolt screwed into the hanger. After this type of cup has been removed from its bolt a few times, the tapped hole becomes considerably worn, owing to the fact that each time it is screwed on the workman endeavors to make it secure by putting it up, what he calls "good and tight."

There is always considerable vibration in a shop, so that it is not an uncommon occurrence to have a cup of this or a similar design work loose and drop from its bolt. When a man is hurt or is given a scare by one of these cups falling, he is not very anxious to have it put back in place, so that a large number of these drip-cups will be found lying in various places, or, in other words, not doing what they were designed for.

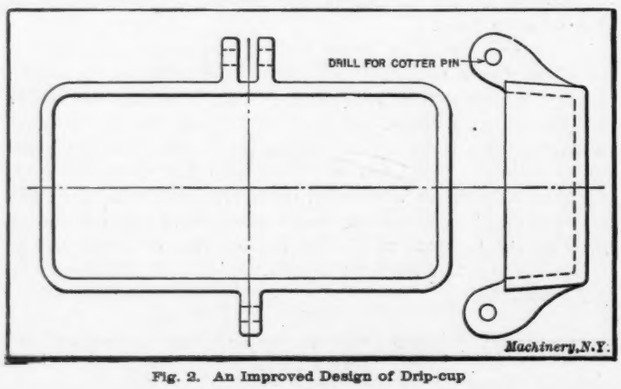


Fig. 2. An Improved Design of Drip-cup

A more efficient type of drip-cup which can be used by designing the hanger with the necessary lugs to hold it in place is shown in Fig. 2. Holes can be drilled in both lugs of the hanger for cotter pins, and with very little extra expense you have a cup which is just as easy to put up—can be emptied by either taking it down or putting a pail under it, after withdrawing one pin—and has the advantage that both pins will not come out at the same time. If it so happened that one pin should come out, the workman would receive a shower bath, which after the first complimentary remarks are over, he forgets. FRANK H. MAYOH

Pawtucket, R. I.

A HANDY BORING-MILL CHUCK

The writer once had charge of a shop where nearly every week it was necessary to machine one or two castings of the

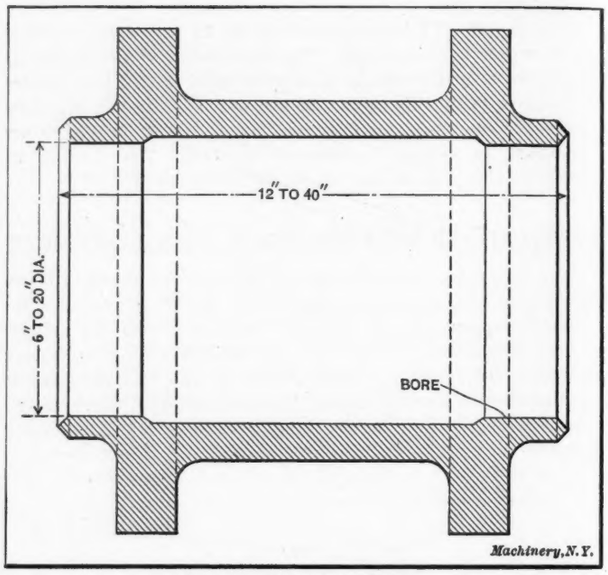


Fig. 1. Casting to be bored

form shown in Fig. 1. These castings had to be bored and the ends beveled as shown. We had to do them on a 52-inch vertical boring-mill, and it took considerable time to rig up and clamp them for boring and facing. The clamping method of holding them did not prove satisfactory, so the writer designed a chuck, the details of which are shown in Fig. 2. This chuck has been used for the past two years for holding the work shown and has given entire satisfaction.

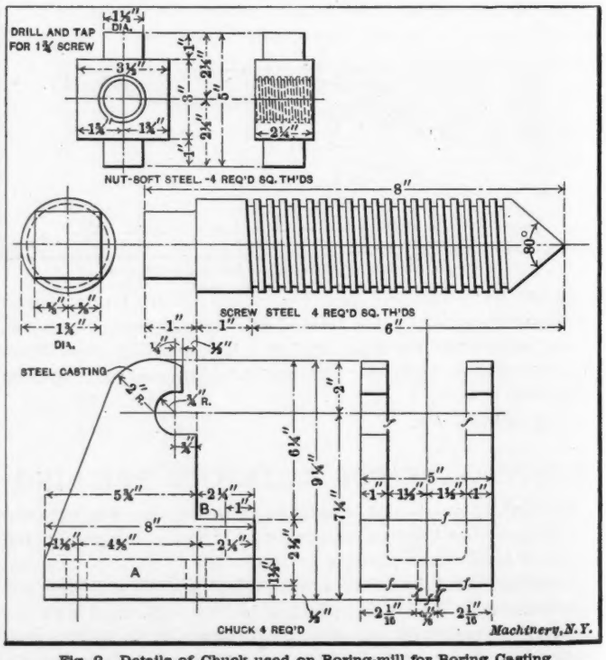


Fig. 2. Details of Chuck used on Boring-mill for Boring Casting shown in Fig. 1

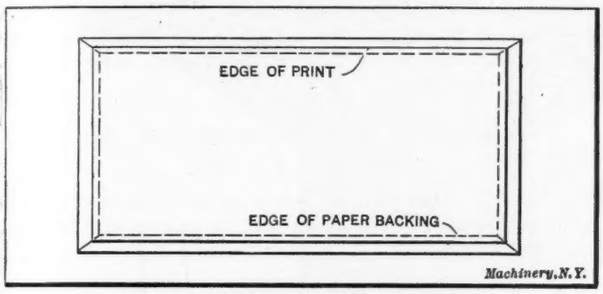
The body or part *A*, of which there are four, are provided with a tongue which fits the T-slots in the boring-mill table, and they are each fastened to the table by two bolts. There is not much strain on these bolts owing to the fact that the flange of the casting rests on the projecting part of chuck *B*, the pointed screws coming in contact with the casting at the junction of flange and body, at an angle of 45 degrees. The screws are in swing nuts to allow moving the casting laterally while chucking; when doing this the clamping screws should be loosened, otherwise they might be bent.

Bradford, Pa. JAMES CLARK

MOUNTING BLUEPRINTS

In the December number of MACHINERY J. B. & Co. ask for a method of mounting blueprints for shop use. The following method has been used by us and has proved satisfactory:

To mount the print cut a piece of No. 25 junkboard to a size that will allow about ¼ inch margin around the blueprint. The junkboard is then backed with a sheet of cheap white paper, the edges of which are folded over on the face of the board and extended about ½ inch in on all sides, as shown in the accompanying illustration. Now fasten the blueprint to the face of the board, and give it a good coating



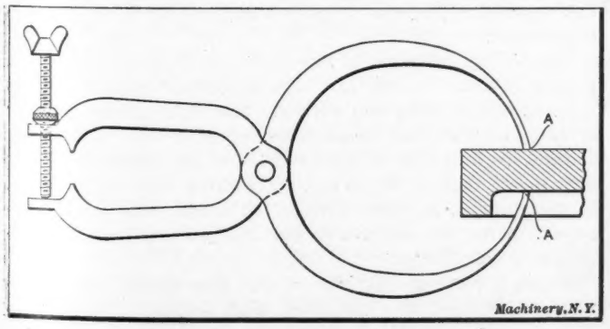
Method of Mounting Blueprints for Shop Use

of white shellac. The object of the paper backing is to keep the mount flat. We have hundreds of blueprints mounted in this manner which have been in constant use, and have given perfect satisfaction. By using white shellac instead of paste, a new print may be placed over an old one which will not crack or loosen, as is usually the case if paste is used.

Rochester, N. Y. H. D. AYLSWORTH

CALIPERS FOR MEASURING OVER A FLANGE

In the August number of MACHINERY several methods of measuring over a flange were shown, and while the methods are all right in their place the writer would suggest what



Calipers for Measuring over a Flange

he considers a still better one. This is accomplished by making a pair of calipers, as shown in the accompanying illustration. The thumb-screw is screwed into the outer end of these caliper legs and a locking nut screwed onto it, which acts as a stop when measurements are to be taken.

To take a measurement proceed in the following manner: Set the calipers so that they bear lightly on the faces of the work, then screw down the thumb-screw until it touches the opposite leg and tighten the lock-nut. After screwing down the thumb-screw the calipers should again be moved around on the work to see that they are adjusted correctly. The calipers are then opened, after which they can be closed to the position at which they were previously set, by means of the thumb-screw and lock-nut. The measurements are taken between the points *A* of the calipers with an ordinary scale.

Philadelphia, Pa. CHARLES H. BETTLE

KEYSEATING LARGE SHAFTS

The article on keyseating large shafts in the August number of MACHINERY was interesting to the writer, as he has had considerable keyseating to do on some large shafts. A description, therefore, of how they were keyseated may be of interest to some readers of MACHINERY. The shafts were

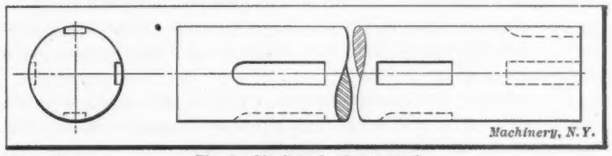


Fig. 1. Shaft to be keyseated

4½ inches in diameter by 52 inches long, and keyseats were to be cut around the periphery 90 degrees apart, as shown in Fig. 1.

The operation of keyseating these shafts was performed on a Burr keyseating miller, and as the shafts were nearly as long as the bed they did not leave room enough for the use of an indexing fixture; so to provide for this an ordinary flanged set-collar was taken and the flange shaped square, as is shown in Fig. 2. This collar was then fastened onto the shaft by a set-screw, and a connecting-rod key placed under it. The shaft was held on V-bolts clamped to the table, as is

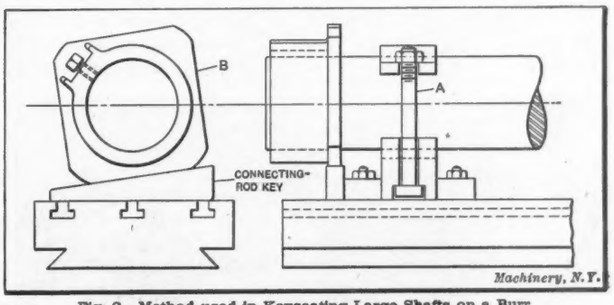


Fig. 2. Method used in Keyseating Large Shafts on a Burr Keyseating Miller

clearly shown in the illustration. After one keyseat had been completed the nuts on the clamping bolts *A* were released, the flanged-shaped piece *B* rotated 90 degrees, and the clamping nuts again tightened. By this method we obtained an accurately divided shaft at very little expense.

Oil City, Pa. JOHN REID

INSERTING SMALL SCREWS

In the July number of MACHINERY a method of inserting small screws was shown, and while it may be effective in some cases the writer thinks that the tool shown in the accompanying illustration would be better. As the illustration shows, this is made from a piece of steel which is slotted, and the slotted end is then spring tempered. To use this "screw-in-

A Tool for Inserting Small Screws

serter," the screw is held in one hand, and the tool in the other; then by springing the slotted end into the slot in the screw, it holds it effectively, so that the small screw can be inserted easily. When the screw is once inserted, this tool can be removed, and the screw put in the remainder of the way with an ordinary screw-driver. FRED HENKE

Philadelphia, Pa.

PREVENTING A PENCIL POINT FROM BREAKING

In the December number of MACHINERY, W. Thompson suggests cutting one end of the pencil round, and forcing on a piece of steel tubing about ¾ inch long, thus making one end heavier than the other, so that when the pencil falls on the floor, the point will not be broken. This appears to me to be more bother than it is worth. In the time spent in rigging up this device the pencil could be resharpened two or three times, and anyway one frequently uses up a pencil completely without its ever having fallen on the floor during its use, so if the steel piece has been affixed, we have lost just so much time which could have been better spent.

If this addition to a pencil were worth all the attention which has been paid to it by contributors at different times, it se ms strange that it should have escaped the attention of pencil manufacturers, and that they should not include such provision in their product.

The scheme of making the end opposite the point heavier, was taken up by one of the large pencil companies some time ago, but did not result very satisfactorily, for the reason that it was tiresome to hold the pencil, as it had to be gripped more firmly than usual on account of the added weight which had to be supported. It also had a tendency to make the pencil wobble around. Anyone, for instance a draftsman, who uses a pencil eight or nine hours a day, will soon be impressed with this point. He will find that his fingers become cramped after holding the heavy pencil for any length of time.

DESIGNER

MACHINE FOR GRINDING SQUARE HOLES

Referring to the November issue of MACHINERY, and the article regarding "Square *versus* Splined Change-gear Shafts", (for automobile transmissions) we notice that your contributor mentions the difficulty of truing up a square hole. It may, therefore, be of interest to your readers to know that some time ago we brought out a machine for grinding holes, by means of which the operation of truing up a square hole becomes a simple and easy matter, and although, as your correspondent suggests, the gears can be made large enough to compensate for any inequalities, yet by the use of the square-hole grinding machine, illustrated herewith, the limits can be made closer, and this machine will enable gears which have closed in a small amount during the hardening process to be finished to the proper size much more quickly than by any methods of lapping. The illustration Fig. 2 shows the arrangement of the essential parts of the machine; *A* is the pulley driving the grinding wheel *B*, *C* is a section of the bar carrying the wheel and pulley. This illustration shows a blank with a square hole in it, with the wheel at work on one side. The blank is indexed around for each side to be ground.

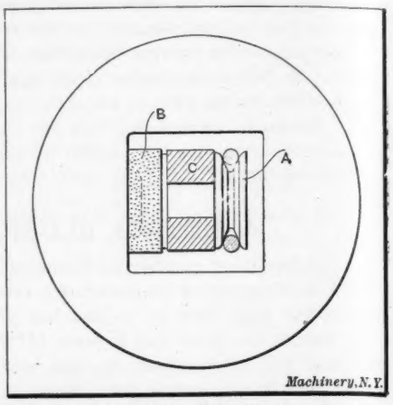


Fig. 2. Cross-section of Grinding Bar showing Wheel at Work

C. W. BURTON, GRIFFITHS & Co.
London, England.

[The square hole grinding machine referred to above was described in MACHINERY, February, 1907; this description may be referred to for further details regarding the construction.—EDITOR.]

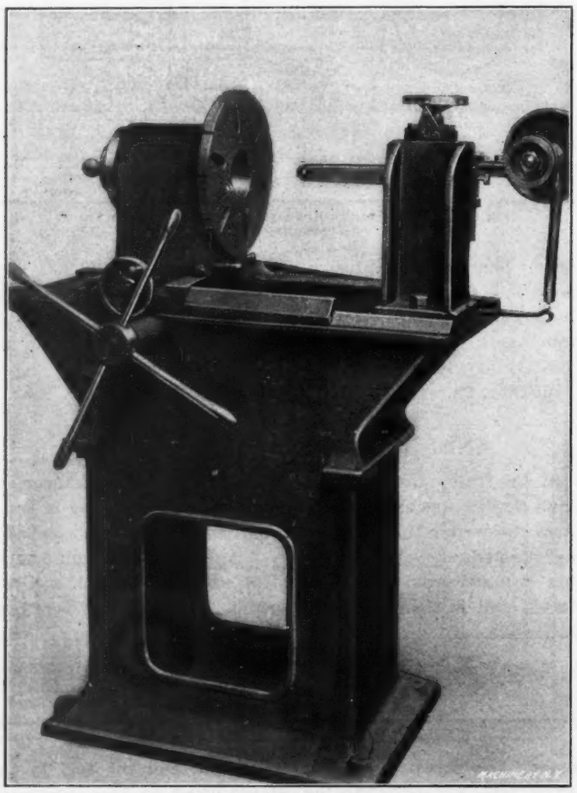


Fig. 1. Burton Griffiths & Co.'s Square-hole Grinding Machine

REBORING LARGE WHEELS ON A SMALL LATHE

A man who has worked mostly in a manufacturing shop and then changes to a regular jobbing shop cannot help but admire the many ingenious ways the men in the latter have of doing things.

Some years ago I worked in a jobbing shop in the South, where I saw a large pulley, about six feet in diameter, brought in to be rebored. As the largest lathe they had only swung thirty-six inches, I thought they would have to rebore the wheel by hand, that is, clamp it on a rig and turn the crank, which is a mean job at the best. It was given to the man on the thirty-six inch lathe, who in about twenty minutes turned his headstock around end for end, with the chuck overhanging the end of the lathe, where he then chucked the pulley in a very short time. A bushing was put in the tapered hole of the spindle, made to fit a boring-bar, which was long enough to reach through the hub. The spindle was clamped in the toolpost of the carriage, and of course, the feed belt could not be used in the regular way, so a large wooden pulley was fastened to the rear end of the feed-rod, and an old belt run over the line shafting. In a little over two- and one-half hours the job was completed and the lathe back where it belonged.

This sort of job came in frequently and I always thought it a good "stunt." I also saw a large pulley chucked in this manner, and rebored and turned. The turning was done by bringing over another small lathe, where it was bolted down at right angles to the pulley, the back of the small lathe being next to the face of the pulley. A turning tool was then put in the toolpost, and the carriage fed along, thus turning the pulley. With the use of a helper this job was done in a remarkably short time.

To me a jobbing shop was always interesting, and it was very seldom that any job grew monotonous. I have often wished since that I could get some of the apprentices that were turned out of that shop.

B. J. F.

* * *

"DRAWING DEEP CYLINDRICAL SHELLS"—ERRATUM

In the article on "Drawing Deep Cylindrical Shells" in the December number the formula $D = \sqrt{d^2 + 4\,dh}$, was given as $D = \sqrt{d^2 + 4\,dh}$, which is erroneous. It was also stated that the drawing punch was fastened to the countershaft plunger; this should have been "crankshaft plunger."

NEW MACHINERY AND TOOLS

A MONTHLY RECORD OF APPLIANCES FOR THE MACHINE SHOP

Comprising the description and illustration of new designs and improvements in American metal-working machinery and tools, published without expense to the manufacturer, and forming the most complete record of new tool developments for the previous month

PRATT & WHITNEY CYLINDRICAL GRINDER WITH AUTOMATIC SIZING ATTACHMENT

The latest development in the cylindrical grinding machinery manufactured by the Pratt & Whitney Company of Hartford, Conn., is shown in Figs. 1 and 2, which are front and rear views, respectively, of a 4- by 30-inch automatic sizing grinder. This machine, which is of the reciprocating table type, contains several features of unusual interest, among which may be mentioned the sizing attachment for automatically grinding duplicate diameters regardless of the wheel wear, and the independent feed pawls which give both roughing and finishing feeds.

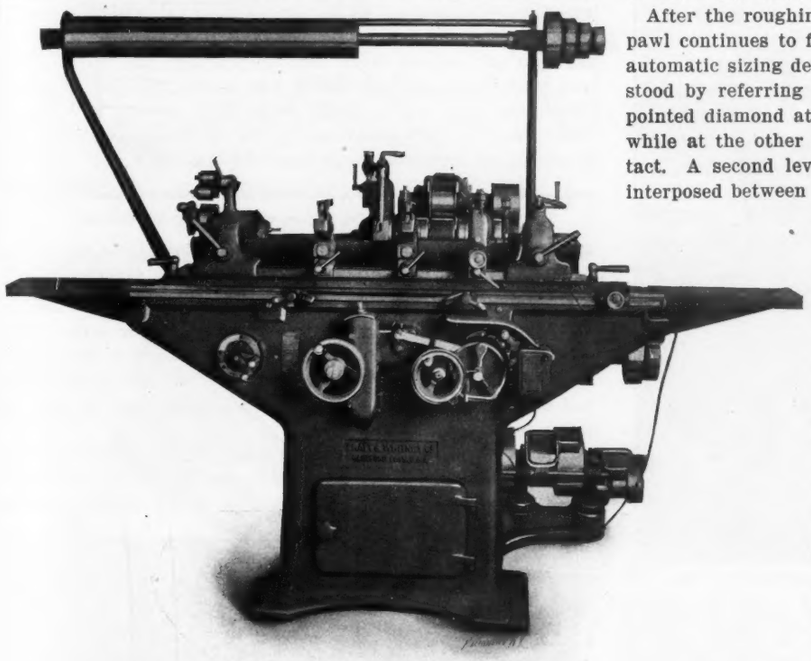


Fig. 1. Front View of the Pratt & Whitney Cylindrical Grinder with Automatic Sizing Attachment

Wheel Feed and Automatic Sizing Device

The construction and operation of the automatic feeding and sizing mechanism will be understood by reference to Fig. 3 and the detailed view of the sizing device, Figs. 4 and 5. The wheel feed proper may be operated entirely independent of the automatic sizing device if desired. The transverse movement of the wheel slide is obtained through a large screw and nut, and it is accurately controlled by the feeding mechanism through encased spur gearing located on the back of the machine. Both roughing and finishing automatic feeds are obtained, as before stated, by means of separate feed pawls *A* and *B* (Fig. 3) which operate upon a ratchet as shown. These feed pawls, while independent of each other, derive their movement from the same connecting lever. Variations in the feeding movement ranging from one-half notch to twelve notches, can be obtained by means of conveniently located adjusting screws, thus giving diameter reductions on the work of from 0.000125 to 0.003 inch. By having two pawls, a feeding movement of ½ notch may be obtained, as stated, when required for finishing. The automatic feed may be instantly engaged or disengaged by a conveniently located knob, or by the automatic sizing device. When setting these two pawls, the roughing pawl *A* might be set, for example, to feed eight notches, while finishing pawl *B* would be set for one notch; the disengager *C* should then be located to disengage the roughing pawl within, say 0.001 inch of the finished size. In setting this disengager, it is important that the set-screw *D* come against stop *E* on the disengager, as this has the effect of automatically maintaining the relation between the roughing and finishing pawls, so that the amount left for finishing always remains the same, regardless of the wheel wear.

After the roughing pawl has been disengaged, the finishing pawl continues to feed until it, in turn, is disengaged by the automatic sizing device, the operation of which will be understood by referring to Fig. 5. The lever *H* carries a smooth-pointed diamond at one end which bears against the work *M*, while at the other end there is a point *K* for electrical contact. A second lever *J* is also provided with contact points interposed between point *K* and point *L* in the frame connecting with a magnet at the front that disengages the feed pawl. As the diameter of the work is reduced, lever *H* drops until point *K* touches the contact point of *J*, which through an electrical connection changes the feed of the wheel and causes it to move against the work at a slower rate. When the work has been reduced to size, lever *H* drops still further, carrying with it lever *J* until an electrical connection is established between the contact points of *J* and *L*, when the fine-feed pawl is instantly disengaged by means of the magnet *F* (Fig. 3) which releases the disengaging trip *G*. This magnet is operated by a dry battery, and its sole function is to disengage the feed, when the work has been reduced to the required diameter.

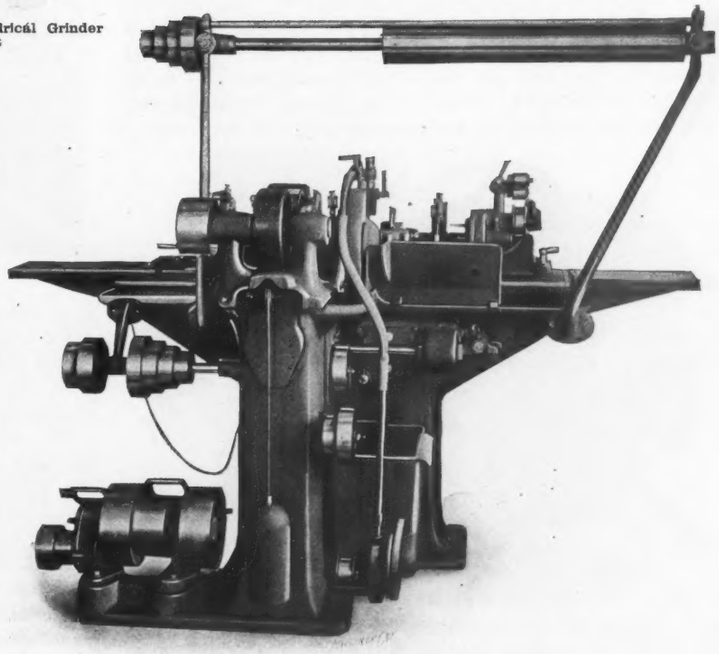


Fig. 2. Rear View of the Automatic Sizing Grinder

When new work is being placed in the machine, the sizing lever is returned to its upper position, both the upper and lower positions of this lever being indicated in Fig. 5 by the dotted lines. In setting this device, a piece is ground to the required size, after which the proper adjustment of the sizing lever is determined by means of a micrometer screw and dial

which governs the transverse adjustment; an adjusting screw is also provided in the sizing lever for very delicate adjustments. This attachment is self-contained, simple in construction, and it may be located in any position on the bed. The connecting wires are encased or insulated to prevent short circuiting, and the voltage required is so low that the dry battery used will last a long time without being replaced.

The Bed and Work Table

The bed of this grinder is massive and well braced internally to insure rigidity and accuracy. It has wide bearing surfaces of the V and flat types. The work table is also well ribbed to prevent warping and to resist torsional strains.

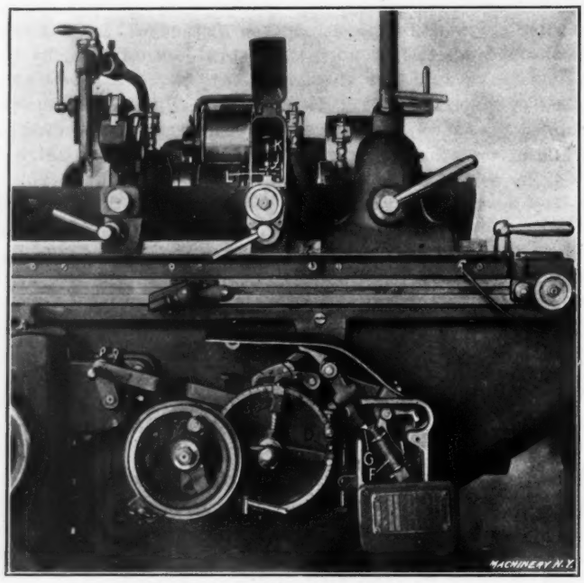


Fig. 3. Automatic Feeding Mechanism

Both the bed and table are made true by means of masters, and the table is made slightly longer than the bed so that the reciprocating movement will tend to keep both members true. The bearings are automatically lubricated by reservoirs and rolls located in the bed, and guards are provided which protect the bearing surfaces. The table may be swiveled for grinding taper work, and the swiveling movement may be accurately determined by means of a micrometer screw and dial. Six changes of table feed are instantly available by means of

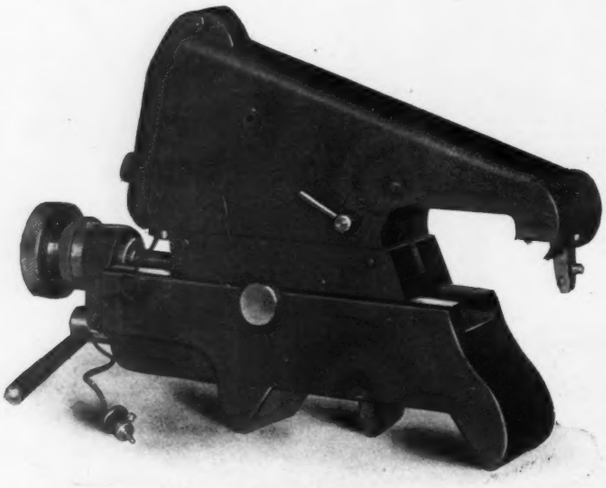


Fig. 4. Sizing Attachment

a change-gear mechanism located at the rear of the machine. These changes are effected by a sliding key that is operated by levers located at the front and within easy reach of the operator. The table feeds are entirely independent of either the wheel or work speeds. The reversing mechanism, which forms a part of this gear box, is of an efficient and substantial type. The point of reversal is determined by the location of dogs on the table that are provided with a sensitive adjustment.

Wheel-base, Wheel-spindle Construction, and Drive

The wheel-base is mounted upon the bed in dovetailed bearings that are provided with a taper gib to compensate for

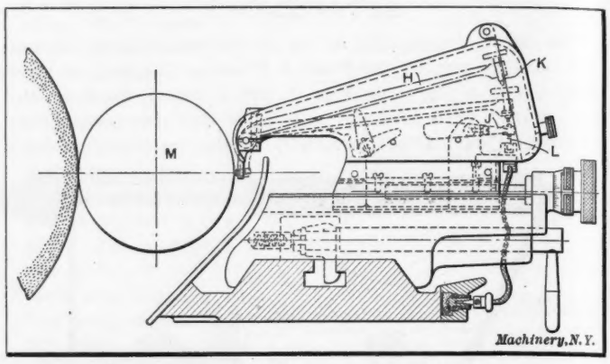


Fig. 5. View showing Mechanism of Sizing Attachment

wear. This wheel-base is heavy but sensitive, backlash in the feed-screw being prevented by means of a weight which is mounted on a roller in such a manner as to obtain the desired result without affecting the sensitiveness of the slide. This weight is shown in the rear view, Fig. 2, which also shows how the slide is mounted directly upon the bed, there being but one working joint between the wheel and bed so that the latter forms a direct support.

The wheel spindle is of tool steel hardened, ground and lapped, and runs in adjustable bronze boxes that are substantially mounted in conical seats. Extra precaution has

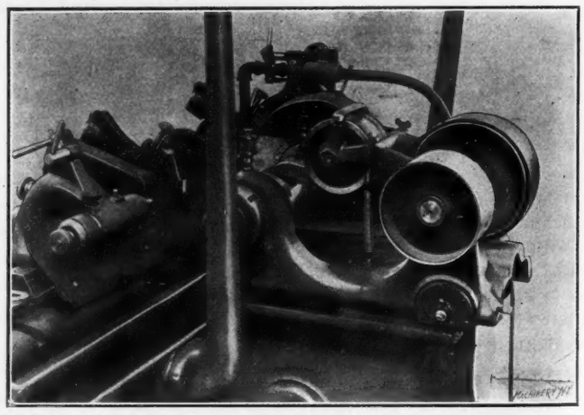


Fig. 6. Side View showing Wheel-spindle Drive and Belt Tightener

been taken to insure proper lubrication, the boxes being provided with self-feeding oilers. The wheel mount is self contained and is so constructed as to hold the wheels firm and true. Provision is made for accommodating wheels 12 inches in diameter and with face widths of from ½ to 1¾ inch.

The drive to the wheel spindle is from a countershaft on the base at the rear, which drives an intermediate shaft on the wheel slide that, in turn, connects with the wheel spindle by an endless belt. With this form of drive, the backward pull of the endless belt keeps the spindle against the inner side of the boxes, thus preventing the wheel from digging into the work if, because of improper adjustment, too large a lubricating space is allowed in the box. As shown in the detailed view, Fig. 6, this endless belt has an automatic tightener which eliminates all upward pull. The downward pull of the belt which connects the intermediate shaft on the wheel slide with the countershaft at the rear, does not interfere with the free movement of the base, as the pressure is taken by a hardened and ground roll in the slide that travels on a hardened and ground parallel in the bed. The makers state that this drive has proved exceptionally efficient and gives ample power under the most severe tests.

Head- and Tail-stocks and Work Table

The head- and tail-stocks may be effectively clamped to the table by means of an eccentric binder, and the offset construction (clearly illustrated in Fig. 6) permits the introduction of efficient water guards. The work revolves on hardened and ground dead centers, and the work driver is gear-driven. The work may be instantly started or stopped independent of the belt drive, by means of a clutch in the head-stock. This gear drive gives ample power, and no trouble has been experienced from chattering or vibration. The tail-stock spindle, which is under spring tension, is quickly operated by means of a rack and pinion. The tension of the spring is varied for different classes of work, by a nut which serves to tighten or release it as desired. An efficient binder is also provided for securely clamping the spindle when necessary. As the engravings show, the work-driving drum is integral with the machine. Four work speeds are obtained through four-step cones, and these speeds are entirely independent of the table or wheel speeds. The cones and drum are accurately balanced which practically eliminates all vibration. A belt tightener for varying the tension on the drum belt, is provided on the head-stock.

Backrests

The backrests employed on this machine are of a new and original design and of such construction that the shoe automatically follows up and supports the work throughout the

Fig. 7. Automatic Positive-feeding Backrest

grinding operation. The proper relation between the work and the supporting shoe is maintained by the downward movement of lever *A*, Fig. 7, which raises the shoe-holder and the shoe as the work is reduced. This downward movement of lever *A* causes roll *B* to advance along its path, which has sufficient inclination to permit the back pressure being taken by the roll without slipping. The pressure is governed by means of adjustable weights located on lever *A*, as shown. When the work has been reduced to the required diameter, the backrest shoe is withdrawn by returning roll *B* to its original position and raising lever *A* to its upper position, where it is held by latch *C*. Both radial and vertical adjustments are provided by means of adjusting screws. This backrest may be easily removed from the bed by a slight inward pressure on the eccentric binder which releases the binding clamp.

Center- and Wheel-truing Devices—Water Supply—Equipment

In order to insure accurate centers, each grinder is equipped with a center truing device, similar to the one illustrated to the left in Fig. 8. This attachment is driven by means of a round belt from the work-drum, and it may be easily located on the table without interfering with the other attachments. The wheel truing device, shown to the right in Fig. 8, is designed to hold a diamond tool, and the wheel may be trued without removing the work or disturbing any other attachments. A liberal water supply is available, there being an efficient type of pump at the rear of the machine and a large water tank, both of which may be seen in Fig. 2. The pipe through which the water is conveyed to the wheel, is so attached to the guard that it may be easily adjusted or instantly removed if desired. A pan of liberal dimensions surrounds the rear of the bed for collecting the water and receiving the chips.

This machine can be furnished with a motor base to accommodate any standard motor. This base is provided with an automatic belt tightener, and a five-horsepower constant-speed motor, having a two-stepped driving pulley for varying the wheel speeds, is used. The regular equipment furnished with this grinder includes the automatic sizing device; one emery

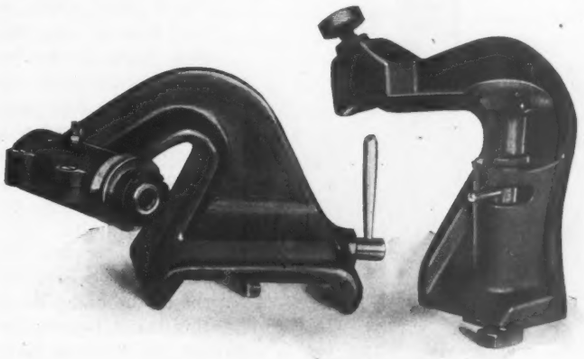
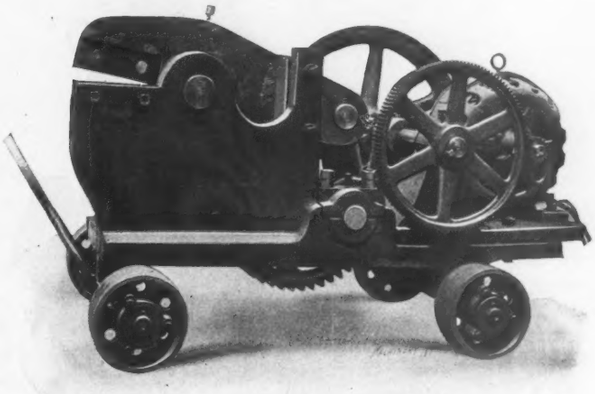


Fig. 8. Center- and Wheel-truing Attachments

wheel; wheel truing device, center grinding attachment; 2 universal backrests; 36 backrest shoes; 16 work dogs; a countershaft, and the necessary wrenches.

LITTLE GIANT PORTABLE SHEAR

A portable shear especially designed for cutting scrap material is now being built by the Danville Foundry & Machine Company, Danville, Pa. As the accompanying illustration shows, this shear is mounted on four wheels which are provided with anti-friction rollers so that the shear may be easily moved about. The drive is by a five-horsepower Westinghouse motor which forms an integral part of the equipment as shown. This motor drives an intermediate shaft which transmits power to a crankshaft connected by a pitman to the movable shear. The knives are 10 inches long and have four cutting edges so that one set of knives is in reality equiv-



Portable Shear built by the Danville Foundry and Machine Co.

alent to four sets. The knives are made of a good grade of tool steel and are capable of long and continuous service. This shear has a capacity for round iron or soft steel up to 1½ inch in diameter, or for square material up to 1¼ inch. The maximum opening of the knives is 3½ inches at the heel. The height from the floor up to the knives is approximately 30 inches. All the gears used in this machine are cut, with the exception of the large one on the steel crankshaft. The crankshaft has a stroke of 6 inches, and it runs in journals having a diameter of 3 inches and a length of 6 inches.

NEW BRITAIN MOLDERS' RAMMING STAND

As there is always more or less work in a jobbing foundry that cannot be done in a molding machine and must, therefore, be hand molded, ramming stands can frequently be used to advantage for this class of work. The New Britain Machine Co., 64 Bigelow St., New Britain, Conn., has placed on the market the design of ramming stand illustrated herewith. With this type, the struck sand falls to each side of the column where it can be easily shoveled up again. The base and top of this stand are machined, and the hollow supporting column, gives the required rigidity. Unlike the wooden devices which rapidly rot in the damp sand, this stand is both durable and fireproof. The top is arranged for holding mold boards with cleets having a center distance of about 10 inches. The height of the stand is 30 inches, and it measures 21 inches front to back. The weight in shipping order is 200 pounds.

New Britain Molders' Ramming Stand

GOULD & EBERHARDT AUTOMATIC GEAR CUTTING MACHINE

One of the latest gear cutting machines designed and manufactured by Gould & Eberhardt, Newark, N. J., is shown in Figs. 1 and 2. This machine is intended for cutting spur, bevel, and face gears, and it is particularly adapted for roughing out automobile bevel gears preparatory to finishing them on a bevel gear planer. It has a capacity for cutting spur gears up to 36 inches in diameter and with a 10-inch face width, and bevel gears up to 24 inches in diameter and 8 inches face width. Teeth up to 3 diametral pitch in cast-iron, and 4 diametral pitch in steel, can be cut in either spur or bevel gears. As the illustrations show, the cutter slide, instead of working horizontally, moves in a vertical plane, and the work is solidly supported on a table that is adjustable on the horizontal ways of the bed. The feeding arrangement for the cutter slide and cutter is on the draw principle, the feed-screw being under tension instead of compression, which eliminates vibration and insures a smooth cutting action. There is also a separate and direct drive to the feed-screw mechanism. This vertical cutting feature gives a rigid and strong construction and eliminates the disadvantage, when cutting bevel gears, of tilting the cutter slide with all its moving parts. The drive to the cutter is also more direct, and the work is rigidly supported, as the strains imparted by the cutter are transmitted to the main base of the machine.

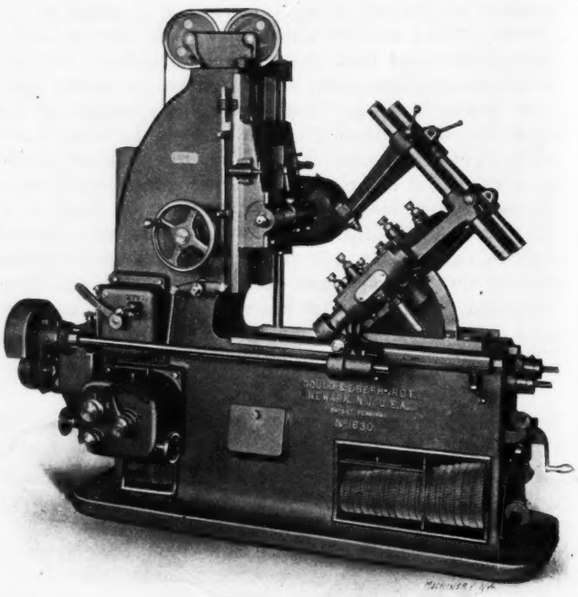


Fig. 2. Gould & Eberhardt Machine set for Bevel Gear Work

The work table is adjustable to any angle and when it is set in an angular position for cutting bevel gears, as shown in Fig. 2, it is supported by a segment arranged centrally and provided with a worm-wheel sector by means of which the table is adjusted. In addition to the locking feature of the worm and worm sector, there is a strap in the segment that enables the table to be rigidly locked when it is properly adjusted. A crank handle at the front end of the machine, enables the operator to adjust the work table by degrees and minutes. One turn of the crank handle indicates one degree, and a sector vernier, graduated in degrees, shows the exact angle to which the table is set. The indexing of the table is controlled by a novel and patented mechanism, which is posi-

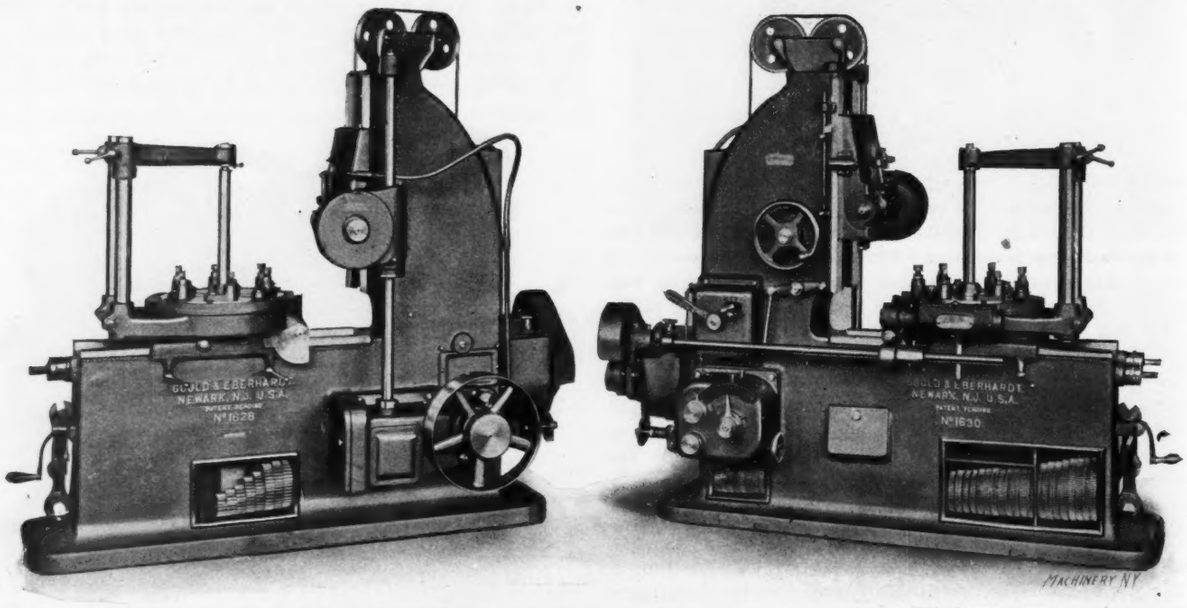


Fig. 1. Gould & Eberhardt "Vertical Cutting" Automatic Gear Cutting Machine

tive, simple in construction, and practically the same as that employed on some of the latest designs of spur gear cutting machines. The last mover of the indexing train is a worm-wheel of large diameter that is rigidly secured close to the work table upon which the gear blank to be cut is fastened. Upon the table, a triangular work mandrel is mounted for supporting the gear blank at its outer end in any angular position. The feed to the cutter slide is controlled by a direct-reading gear-box which enables the different feed variations within its range to be quickly obtained. This gear box provides for 16 different feeds ranging in geometrical progression from 1 inch to 15½ inches per minute, and any of the various feeds may be obtained by the operation of two handwheels. The cutter slide is counterbalanced and it is provided with a rapid return. The feeding, indexing and return movements are interlocking so that the succeeding movement cannot take place until the preceding movement is entirely completed. The cutter driving mechanism is of the simple and direct form found in the spur gear cutting machines built by this company. The cutter is driven by a steel worm and bronze worm-wheel of special construction which insures smooth running and a powerful drive. The cutter arbor is made of chrome-nickel steel and it can accommodate different sized bushings to permit the use of cutters having holes of various diameters. The speed variations for the cutter spindle vary in geometrical progression from 23 to 145 revolutions per minute, the different changes being effected through change gears. The machine is driven by a single driving pulley, as shown to the left in Fig. 1, and all gears are entirely enclosed by guards. The machine weighs 3500 pounds, and, if desired, it may be equipped with an electric drive. It is especially adapted for roughing out nickel steel automobile driving gears and pinions, and the makers state that it has already been placed in many of the prominent automobile factories.

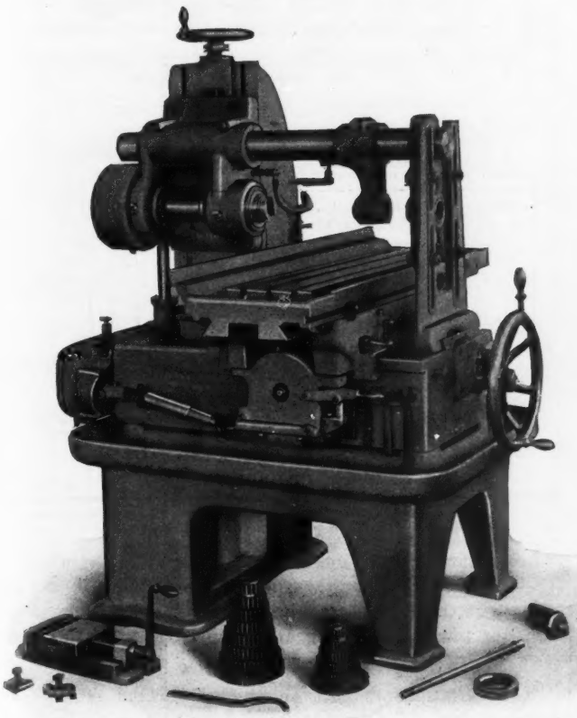


Fig. 1. Brown & Sharpe 34- by 6- by 12-inch Plain Milling Machine

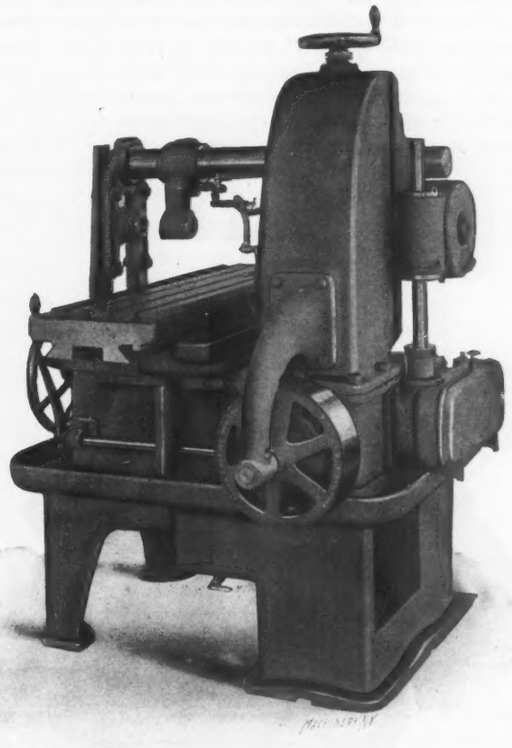


Fig. 2. Showing Constant-speed Driving Pulley and Clutch-controlling Lever

BROWN & SHARPE NO. 13 B PLAIN MILLING MACHINE

The Brown & Sharpe Manufacturing Company, Providence, R. I., has brought out a new design of milling machine of the manufacturing type, embodying in its construction a number of interesting and important features which adapt it to modern manufacturing methods and the production of duplicate parts. This machine, different views of which are shown in Figs. 1 to 3, is of the constant-speed drive type, and it is adapted for either belt or motor drive. As the engravings indicate, the construction is very rigid, the upright which supports the spindle head being of the box form, and the bed and saddle being so constructed as to give a maximum support to the table—an essential feature on a machine of this type, which is often required to take heavy cuts. In this connection it should also be noted that the saddle has large bearing surfaces on the bed. The location of the operating levers and handwheel, and the facilities for changing speeds and feeds are also noteworthy features. The spindle, which is made of crucible steel, is heavy and it has large bearings that are accurately ground and correctly proportioned to withstand hard service. There is a standard taper hole in the spindle, and the front end is threaded to receive a chuck or large cutter; there is also a slot across the end for driving an arbor or collet having a clutch collar. A draw-in bolt is also furnished for holding arbors, etc. The spindle boxes are made of phosphor-bronze and they are provided with means of compensating for wear.

The Spindle Drive

As the machine is of the single-pulley type, the drive may be direct from the main line if so desired. The driving pulley is 14 inches in diameter, 4½ inches wide, and runs at a speed of 300 revolutions per minute, which gives a powerful and efficient drive. A friction clutch is located in the driving pulley and provides means for starting and stopping the machine. This clutch is operated by a vertical lever that is located to the right of the large handwheel. Figs. 4 and 5 illustrate how the drive is transmitted to the spindle. The main driving shaft *A* upon which the constant-speed pulley is mounted, is connected through bevel gearing with the shaft *B* which transmits the movement through the change-gears *C* and *D* to the shaft *G*. This latter shaft, in turn, is connected through bevel gearing with shaft *H* upon which is mounted a hardened steel worm that meshes with the large bronze worm-wheel *J* to which the spindle is keyed. The worm gearing runs in oil and furnishes a smooth and powerful drive. Provision for wear in the worm is made in the following ways: The adjustment of the worm for end thrust is obtained by loosening the screw *a* and tightening nut *b*;

this forces bushing *c* against the worm which has a ball thrust bearing at its opposite end, as shown. To compensate for backlash between the worm and wheel, the nut *d* is loosened, which releases the bushing *K*. As the shaft *H* is mounted eccentrically in its bearings, the screws *e* and *f* are then adjusted until the proper center distance is established between the worm and wheel and backlash is removed.

Table Feeding Mechanism

The method of transmitting the feeding movement to the table is indicated in Figs. 4 and 6, which show, respectively, a sectional view of the change-gear case, and a longitudinal section of the table. The power is transmitted from shaft *B* through the spur-gears *E* to the shaft *F* which is connected through change-gears *M* and *N* to the shaft *L* which, in turn, is connected by sliding gear *O* and gear *P* (either directly or indirectly, depending upon the direction of the feed) with the universal-joint shaft *Q*. Shaft *Q*, through the worm gearing shown in Fig. 6, drives the shaft *R* which transmits the movement to the table through bevel gears and a rack and pinion. A quick return for the table is obtained by means of the large handwheel seen at the front of the machine, after the driving worm *W* has first been disengaged from its wheel by operating the lever seen at the left of the bed in Fig. 1. By referring to Fig. 7, it will be seen that the large handwheel *S* controls both the longitudinal and transverse feeds. Normally this handwheel is used to operate the longitudinal feed, and when so used, it is in the position indicated in the illustration. When the operator desires to adjust the table transversely, the

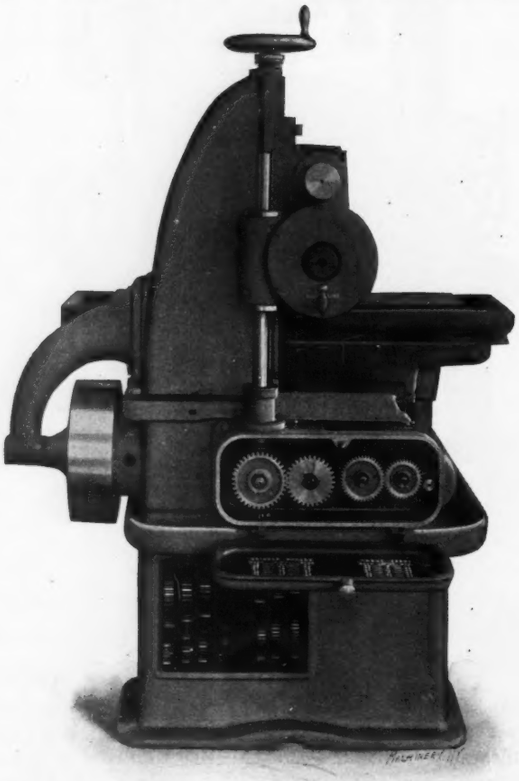


Fig. 3. Rear View showing Change-gear Case and Cabinet Base

handwheel is pushed in against the tension of spring *h*, thereby disengaging the clutch at *T* and engaging the spur-gear *U* with a corresponding gear located on the screw which controls the transverse adjustment. As most of the adjustments are in a longitudinal direction on a machine of this type, the spring *h* is employed to automatically engage the handwheel with the longitudinal feed as soon as the transverse adjustment has been made. With this construction, an independent handwheel for the transverse feed is avoided, though one wheel has, as the result, a double function; this, however, should not be confusing to the operator, inasmuch as the cross movement is only required occasionally, and the wheel is normally held in the position where it is most used. The longitudinal feed of the table is positive and automatic in either direction, and it can be automatically released at any point.

The mechanism for reversing the table movement is illustrated in Figs. 4 and 8. The gear *O*, which is the driving member, is free to slide on the shaft *L* and its position is controlled by the rod *V* which extends to the front of the machine. To reverse the feed, gear *O* is moved along by the knob on rod *V* (which may be seen to the left of the hand-

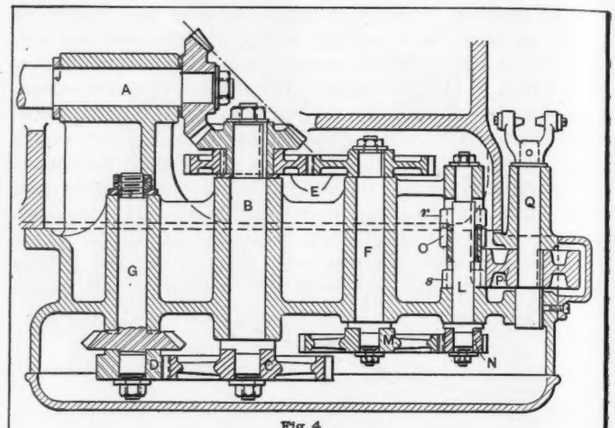


Fig. 4

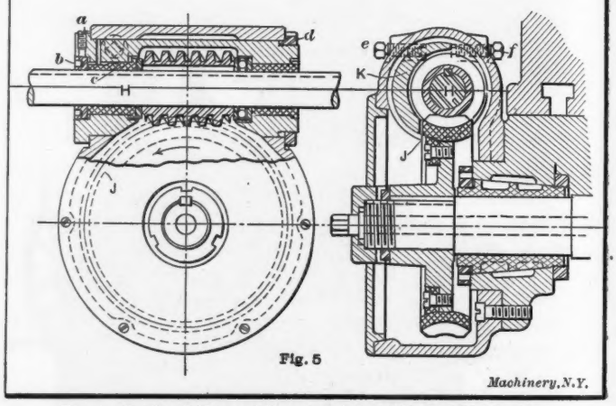


Fig. 5

Machinery, N.Y.

Fig. 4. Sectional View of Speed and Feed Change Mechanism.
Fig. 5. Worm Gear Drive for Spindle

wheel) until it is in mesh with gear *r*. Gear *s*, which is on the same shaft with *r* transmits the movement to the gear *P* and shaft *Q*. For feeding in the opposite direction, gear *O* is brought into mesh with gear *P*, thus giving a direct drive.

Speed and Feed Changes

The variations in both spindle speeds and table feeds are obtained by means of change-gears, which, when not in use, are kept in a wooden cabinet in the base of the machine. The tables of speeds and feeds, together with directions for making the changes, are cast in the case cover, which is shown open in Fig. 3. Particular attention has been given in the design to the matter of attaching the change-gears for obtaining speed variations, the gears being held in place by clutched hubs and split washers, which enables them to be readily removed without taking off the nuts. Eight changes of spindle speed are available, ranging from 20 to 124 revolutions per minute and varying practically in geometrical progression. There are also eight feed changes ranging from ¾ inch to 9 inches per minute. These are independent of the spindle speeds and also vary practically in geometrical progression.

Miscellaneous Features

A vertical adjustment is provided for the spindle head, which is operated by the handwheel seen on the top of the upright. This handwheel has a graduated collar reading to thousandths of an inch. The spindle head slides in dovetailed ways and can be rigidly clamped to the upright by the four bolts shown. The overhanging arm is a solid, accurately ground steel bar, which can be pushed back out of the way when not in use. There is an arm support especially designed to secure rigidity, and an arbor support that can be used at

any intermediate point near the cutter. Both of these supports are fitted with bronze bushings which furnish bearings for the arbor. In addition to the graduated collar on the handwheel for the vertical adjustment, there is a dial graduated to thousandths of an inch for indicating the transverse movements of the work table.

The base of this machine is heavily built to insure rigidity and it rests on two legs in front and a cabinet pedestal at the rear. There is an oil pan extending around the base to catch waste oil, which drains into a tank large enough to provide an ample supply of lubricant. A pump is included in the equipment and the channels in both the table and saddle for catching the lubricant have been made extra large, as shown in the different views.

The general specifications of this machine are as follows: Longitudinal feed, 34 inches; transverse feed, 6 inches; vertical adjustment, 12 inches; distance from center of spindle to under side of arm, 5½ inches; maximum distance from end of spindle to arbor bushing with arm support in position, 22½ inches; working surface of the table, 12½ by 40 inches. A flanged vise having jaws of hardened tool steel, 6⅛ inches wide, 1 9/16 inch deep, and a maximum opening of 3⅝ inches, is included in the equipment. The net weight of the machine is about 3800 pounds.

NEWARK AUTOMATIC SPUR GEAR CUTTING MACHINE

An automatic spur-gear cutting machine that is manufactured by the Newark Gear Cutting Machine Company, 66 Union St., Newark, N. J., for heavy spur-gear work, is shown in Figs. 1 and 2. This machine has a capacity for gears up to 84 inches in diameter, 24-inch face, and it will cut teeth having a circular pitch of 6 inches. This is the largest and most powerful machine of the horizontal cutting type made by this company, and a good idea of both the size and general construction can be obtained by reference to the illustrations.

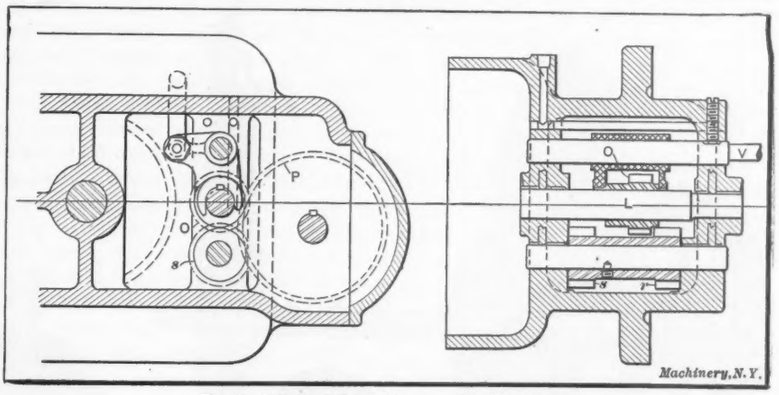


Fig. 8. Detail of the Table-reversing Mechanism

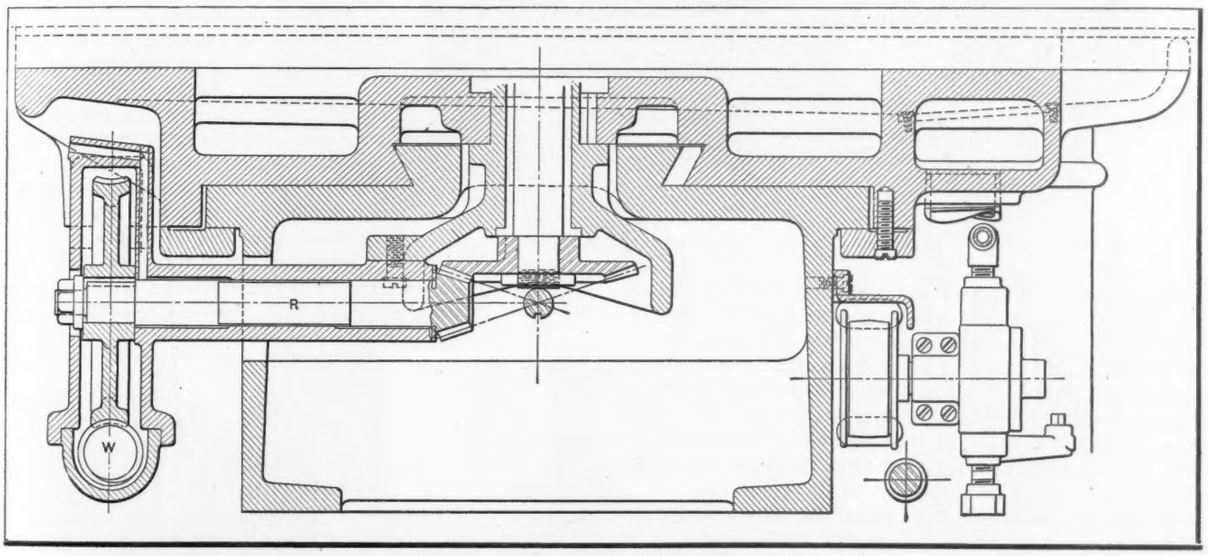


Fig. 6. Longitudinal Section showing Table Drive and Hand Feed

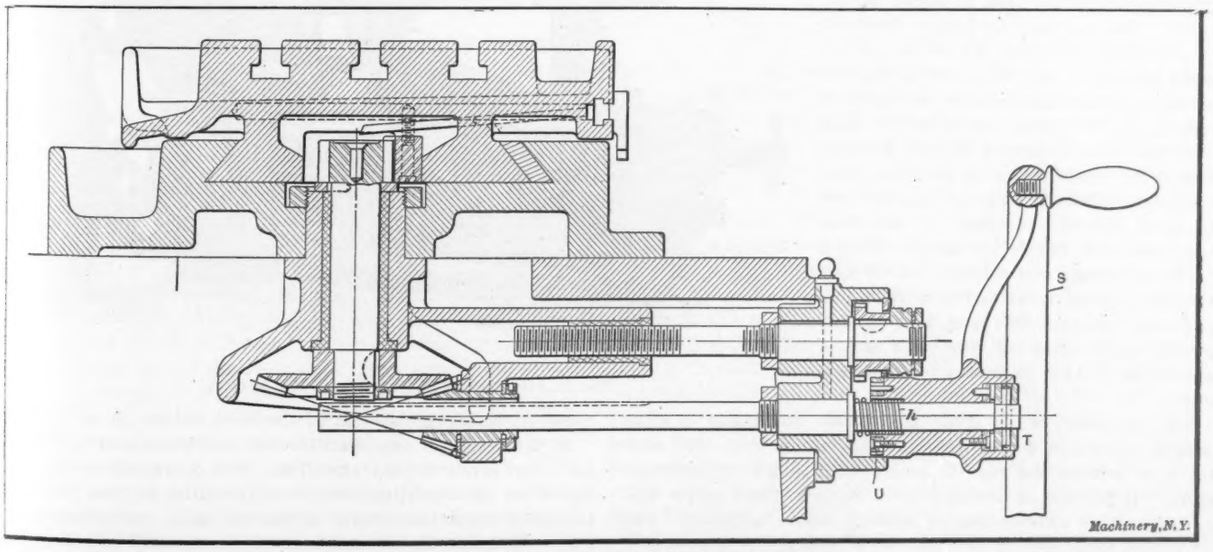


Fig. 7. Transverse Section showing Table Drive and Hand Feed

The machine is driven by a single pulley which runs at a constant speed of 300 revolutions per minute. The cutter spindle, which is a crucible tool steel forging, is provided with a taper hole to receive cutter arbors. The arbor is drawn into and forced out of the spindle by means of a draw-in bolt, positively, without hammering. The spindle and arbor are amply heavy to permit the use of a gang of finishing cutters, or a gang of finishing and roughing cutters side by side on the arbor. The spindle is driven by means of a powerful spur-gear train, and various speed changes are obtained by means of change gears placed as near the last driver as possible. This allows the driving shafts to rotate at constant speed, and avoids undue strains in the shafts when the cutter is running at a slow speed on heavy pitches.

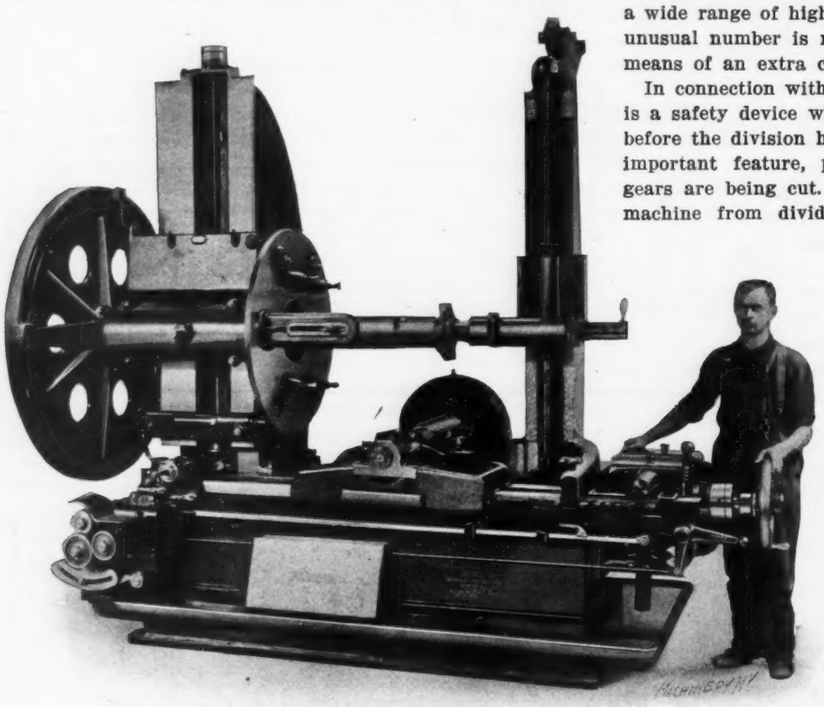


Fig. 1. 84- by 24-inch Automatic Spur-gear Cutting Machine built by the Newark Gear Cutting Machine Co.

The changes in the feed of the cutter carriage, are also obtained by means of change gears; but the rate of the cutter speed and the rate of the carriage feed are independent of each other, so that one may be changed without affecting the other. The carriage quick-return is constant, not being affected by the feed or speed of the cutter. The carriage feed-screw operates on the draw principle, the thrust collars being placed so that the screw is not subjected to compression strains, either when feeding or returning the carriage. This drawing action insures a smooth uniform feed to the carriage, with freedom from vibration. By referring to Fig. 1 it will be seen that the carriage is especially long, and that the cutter spindle bearing is in the center of its length. This construction prevents chattering or vibration, and as the bearings are long, with narrow guides, the action of the carriage is smooth, even when operating under severe duty.

The indexing or dividing mechanism comprises a large master-wheel and a positive actuating mechanism. The master is a worm-wheel that is generated in place on each machine. It is made in sections, there being a wheel proper and a ring, which construction is used to insure accuracy. The master-wheel receives its movement through a positive indexing mechanism which embodies a very simple clutch mechanism, requiring no adjustment. The various divisions for different numbers of teeth are obtained by means of change gears, which provide for cutting all numbers of teeth up to 100, and all numbers from 100 to 450, except prime numbers above 100; a wide range of higher numbers can also be cut. When any unusual number is required to be cut, this can be done by means of an extra change gear.

In connection with the positive indexing mechanism, there is a safety device which prevents the carriage from feeding before the division has been correctly completed. This is an important feature, particularly when large and expensive gears are being cut. A safety mechanism also prevents the machine from dividing when an obstruction on the gear blank, such as a lug or flange, would collide with the rim support and injure the gear or the machine, were it not for the safety device. This mechanism is entirely automatic, and does not require any setting or adjustment, as it operates regardless of the size of the gear or the number of teeth being cut. It also is valuable because of the interlocking feature which prevents the operator from engaging the feed mechanism while the machine is dividing.

The work spindle is of large diameter and is accurately ground. It is provided with a taper hole to receive work arbors, and a draw-in bolt acts to draw the arbor in and force it out, positively. The work head is of massive proportions, and is so gibbed to the head that the alignment is maintained without regard to which clamping bolt is tightened first. The head is provided with a screw and micrometer dial graduated to read to thousandths of an inch. Power mechanism is provided for quick adjustment of the head, either up or down.

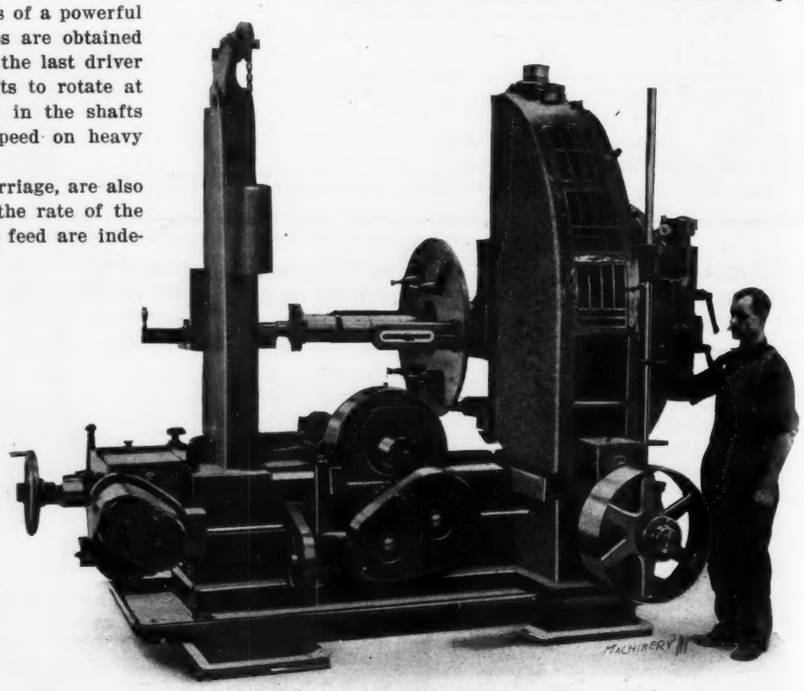


Fig. 2. Rear View of Newark Gear-cutting Machine

In the design of this machine, the convenience of operation has been given special attention. The operating levers are placed on the operating side of the machine, so that they are instantly under the control of the workmen. A conveniently

located lever controls the engagement of the power feed to the cutter carriage, and an index lever is used to trip the indexing mechanism, when setting the machine, or to set the machine to rotate the blank continuously. If desired, the feed can be set so that the carriage will feed and return, without having the blank indexed; this is useful when setting. The carriage handwheel is self disengaging, so that it does not revolve when the power feed is engaged. An oil pump is supplied for furnishing an ample supply of cutting fluid, when cutting steel gears.

W. E. GANG CO.'S RADIAL DRILL

A design of radial drilling machine that is now being manufactured by the Wm. E. Gang Co., of Cincinnati, Ohio, is shown in Fig. 1. This machine has all the modern improvements which are considered essential to accuracy and rapid production, and the design is symmetrical and pleasing in appearance. As the illustration shows, the matter of convenience in the location of the various controlling levers has also received careful attention. Hardened steel gears are used in both the driving and feeding mechanism wherever severe duty is encountered, and all journals are bronze bushed. The splash system of lubrication and direct oiling devices, are used throughout. All gears are encased by housings which are built in the design, retaining the lubricant, excluding the dust, and protecting the workmen from injury. All shafts are supported by bearings at each end, which construction insures durability as well as rigidity, and holds all running parts in alignment.

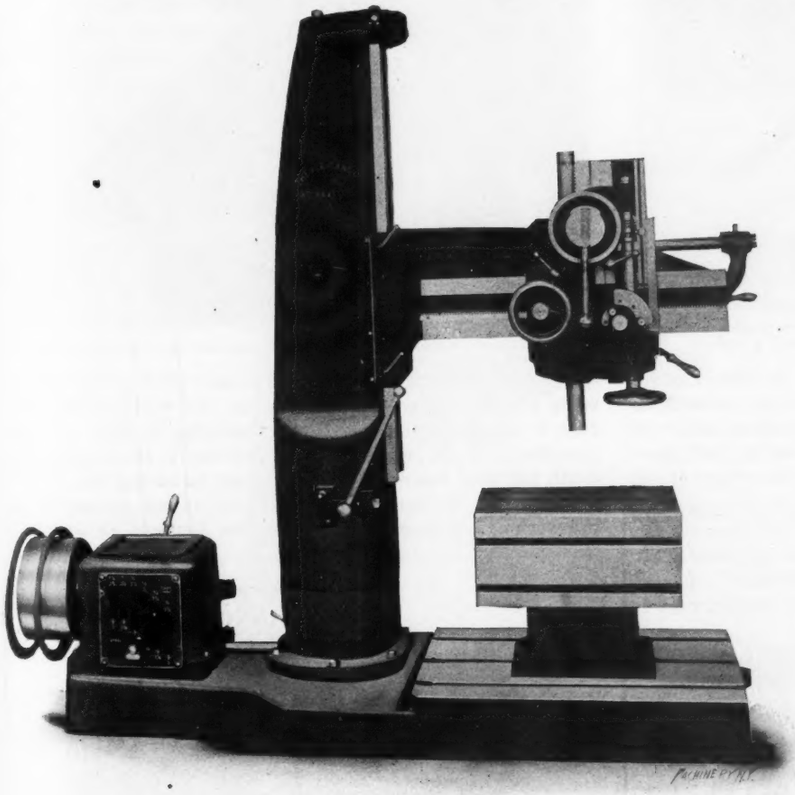


Fig. 1. Radial Drill built by the Wm. E. Gang Co.

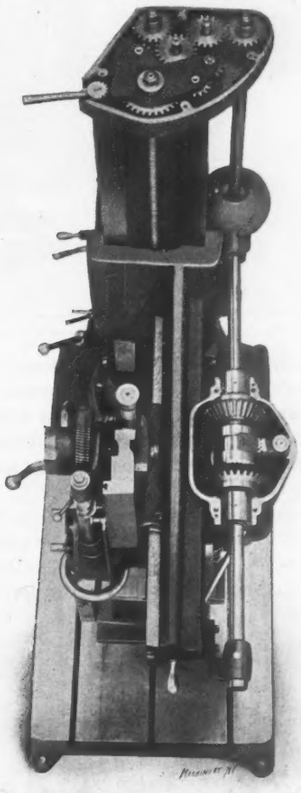


Fig. 2. Plan View of the Gang Radial Drill

The base of the machine, which measures 6 feet 3 inches by 28 inches, is deep, heavy, and well ribbed. The arm which has a radius of approximately 4 feet, is also rigid, being heavily webbed and of the D section. This arm is raised and lowered by power, the movement being controlled by the lever seen at the top of the column. The speed box is of the selective type and consists essentially of a cone of six gears running in oil, and a lever carrying a tumbler gear which transmits the power from the constant-speed pulley shaft to the cone of gears. There are twelve changes of speed available, six of which are obtained from the change-gear box, which number is doubled by the back gears located in the head. The speed variations range from 39 to 280 revolutions per minute, and are suitable for drills varying in diameter from ½ inch to 2¾ inches in cast-iron, and from ⅜ inch to 2 inches in steel. The correct position of the speed box lever for drills of different sizes, when drilling either cast-iron or steel, is shown by a plate attached to the speed box.

Tight and loose pulleys are provided on the machine, so that it can be driven direct from the line shaft, and the band shifter rings used, permit the belt to be delivered to the pulley at any angle. These pulleys are intended for a 3-inch belt, and the speed is 350 revolutions per minute. The column revolves upon a stationary pedestal which forms practically a double column, there being a bearing both at the top and base. The weight of the column is taken by a roller thrust bearing which gives a free swinging movement, and the column is securely clamped by the slight movement of a lever that lifts it away from the rollers so that they cannot be embedded in their race.

The construction of the head and the location of the various controlling levers is more clearly shown in the enlarged view, Fig. 3. The head is adjusted on the arm by a rack and pinion actuated by handwheel *A*, and it is clamped by lever *B*. The spindle can be quickly advanced and returned by using the lever *C* and it is provided with a reverse motion for tapping that is controlled by lever *G*. The spindle is counterbalanced by a slide or weight *D* which has a rack on one side that engages with a pinion meshing with the spindle rack (as indicated more clearly in Fig. 5) so that the two parts move in unison. The back gears are located in the head between the friction reversing clutch and the spindle, as shown in the sectional view, Fig. 6. When the drive to the spindle is direct, the power is transmitted from the vertical shaft *N* through the gears *A*, *D* and *E*, the clutch *O* which is operated by a small lever at the side of the head being engaged with gear *A*. When the drive is through the back gears, the clutch *O* is engaged with gear *B* which transmits the movement through gears *C*, *D* and *E* to the spindle. The clutch *O* is indexed by a spring plunger that engages suitable holes for either of its two positions.

The feed-changing mechanism located in the head, provides

variations ranging from 0.007 inch to 0.036 inch per revolution of the spindle. Any of these changes can be instantly obtained by shifting the levers *E* and *F*, Fig. 3. The feed, in thousandths of an inch, obtained for the different positions of these levers, is shown on the index plate, and both levers are positioned by a spring plunger, as the engraving indicates. The way the feeding movement is transmitted from the spindle

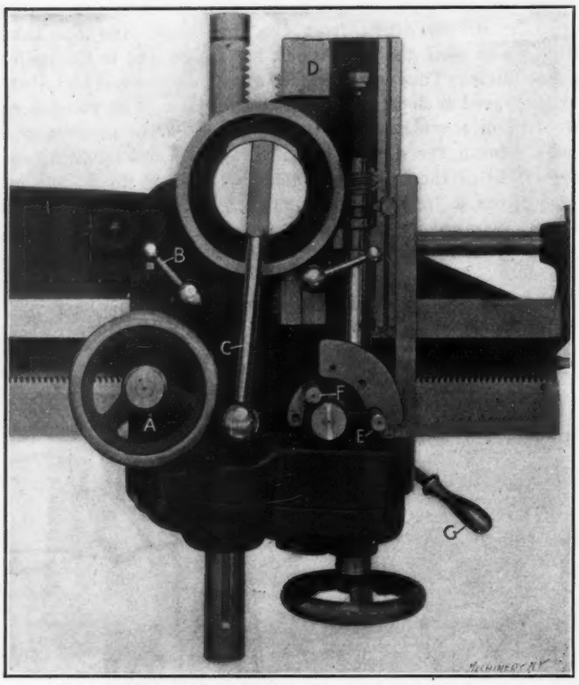


Fig. 3. Enlarged View of Head showing Controlling Levers

to the driving worm shaft, is clearly shown in Figs. 4 and 5. Fig. 4 shows the lower case dropped down, thus exposing the gears and clutches, and Fig. 5 is a diagrammatical section of the head. The same reference letters are used in both these illustrations for corresponding gears, and the order of the

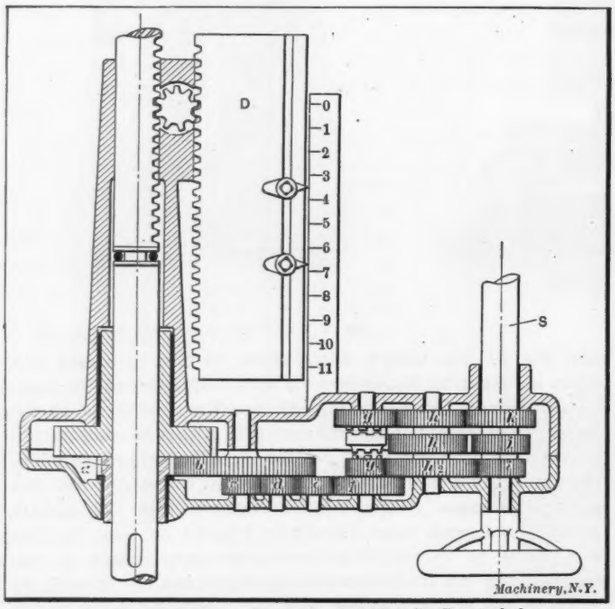


Fig. 5. The Feed-change Mechanism and Spindle Counterbalance

letters indicates the way the power is transmitted. The gear *a* on the spindle, drives, through a train of intermediate gears *b*, *c*, *d*, *e*, and *f*, either gear *g* or g_1, depending upon the position of the clutch between them, which is controlled by the lever *F*, Fig. 3. Either gear *g* or g_1 drives, in turn, a solid cone of gears h, h_1 and h_2, meshing with the gears *i*, *j* and *k* that rotate the driving worm shaft *S*. By connecting either of these latter gears with shaft *S*, three feed changes are obtained, which number is doubled by operating the clutch connected with *g* and g_1.

A depth gage is provided on this machine which consists of a graduated scale mounted on the head just to the right of the counterbalance, as shown in Fig. 5. The counterbalance carries an adjustable pointer (or several pointers if desired) which is set to the required depth rather than at zero, so that

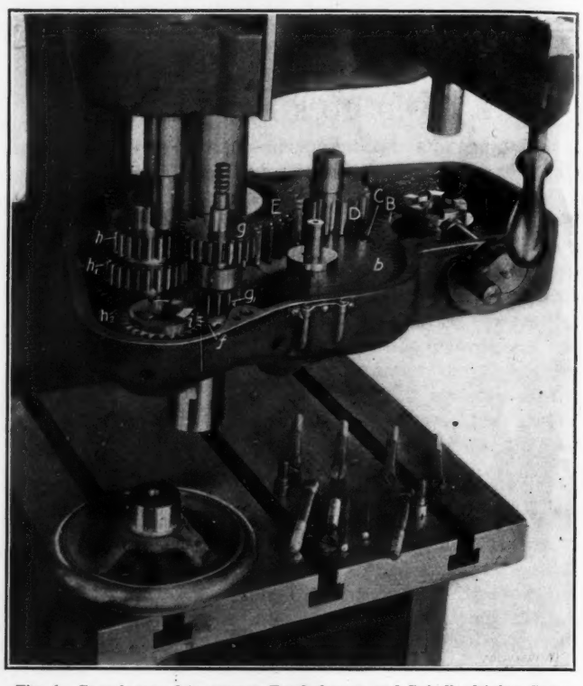


Fig. 4. Case lowered to expose Feed-change and Spindle-driving Gears

the pointer moves upward toward the zero mark as the hole is being drilled. With this arrangement, the workman sets the gage to the depth required before beginning to drill, and the coincidence of the pointer with the zero mark, shows when the depth has been reached. The advantage in having the pointer move *toward* the zero mark is that it is not necessary for the workman to keep in mind what the depth is, as would be

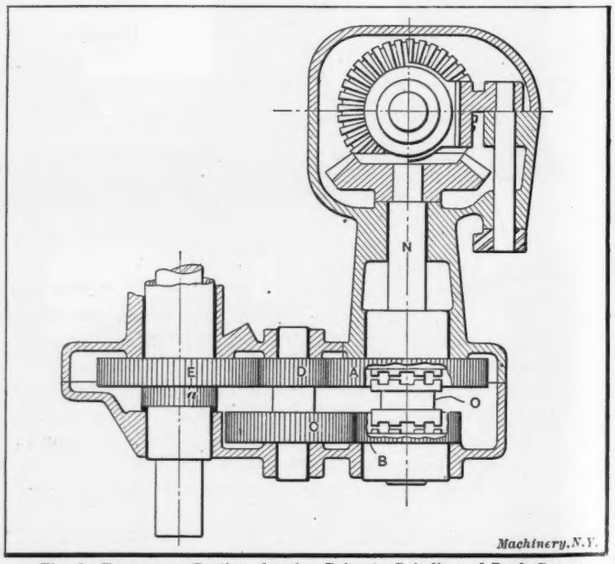


Fig. 6. Transverse Section showing Drive to Spindle and Back Gears

the case if the pointer moved *from* the zero position to the depth graduation. The feeding mechanism is provided with automatic trips which may be set to operate at different depths. These trips do not interfere with the movement of the spindle, which can be adjusted up or down irrespective of their position. Provision is also made for automatically tripping the feed when the spindle reaches the limit of its movement.

By referring to the plan view of the machine, shown in Fig. 2, the position of the spindle reversing gears and their clutch, and the gears for operating the elevating screw, as well as the relative positions of the levers and other parts, may be seen. These machines are equipped with a 16- by 24-inch plain box table, or, if desired, with a tilting table on the base. They are built in 2½-, 3- and 3½-foot sizes. The particular machine illustrated is the 2½-foot size, and it has a net weight of 3600 pounds.

FOX MULTIPLE-SPINDLE DRILLING MACHINE

The Fox Machine Co., 1612 N. Front St., Grand Rapids, Mich., has redesigned its No. 3 multiple-spindle drilling machine, as shown by the accompanying engraving. This machine is intended to handle a class of work of medium weight, requiring neither very light nor very heavy drilling operations, such as automobile engine bases and similar parts. The driving pulleys on this design are located on the base at the rear, as shown, and transmit power to a single pulley at the top of the column which drives the drill spindles through a change gear mechanism. By having the main driving pulley located on the base instead of at the top, the vibration when drilling, is reduced to a minimum. The pulleys are of large diameter and have broad faces, thus insuring ample power. All drill speed changes are obtained through a system of sliding gears,

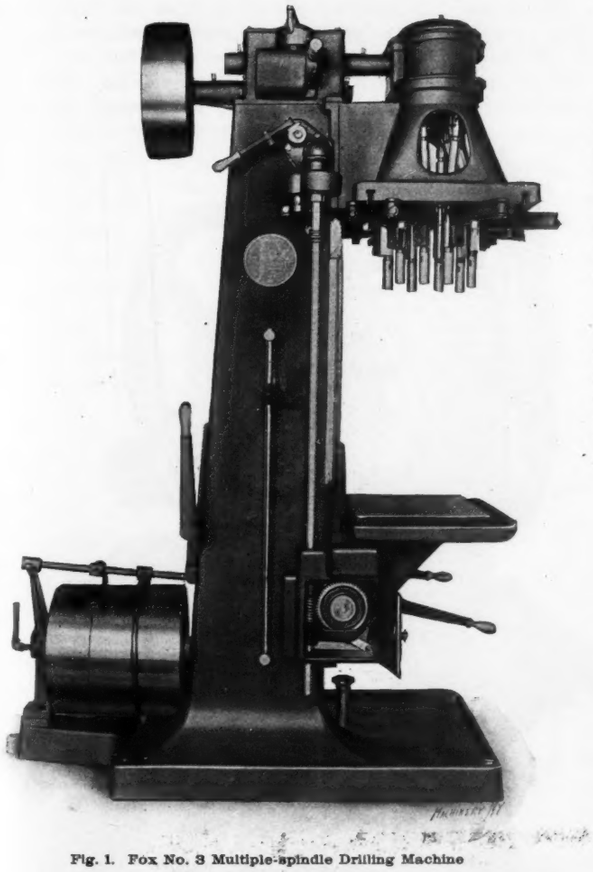


Fig. 1. Fox No. 3 Multiple-spindle Drilling Machine

and the feed changes for the drilling table are effected in the same way. Four changes of drill speeds are available and six changes of drill feeds. The column of this machine has been made extra tall to permit the use of high jigs on the table. The maximum distance from the surface of the table to the under-surface of the head, is 43 inches, and the travel of the table is approximately 30 inches. All the main bearings are of special bronze and are provided with ample means for oiling. The principal gears are of chrome-nickel steel and have broad faces. The gears in the head are encased and run in an oil bath. This machine is equipped with drill spindles and bearings of special construction which allows the drilling of holes having the same center distances as the diameter of the drill spindles. One of these spindles and its adjusting arm is shown in detail in Fig. 2. The universal joints used are the company's own construction. This type of machine can be furnished for drilling holes as follows: Ten ¾-inch holes; eight ⅞-inch holes; fourteen ½-inch holes; sixteen ⅝-inch holes; twenty ¼-inch holes, and twenty-four 3/16-inch holes. These holes can be drilled in either aluminum, cast iron, or steel. The drill table on this machine measures 17 by 22 inches. The drill head can be furnished in either round or rectangular shapes. The machine occupies a floor space of 6 feet by 2½ feet and its overall height is 7 feet 8 inches.

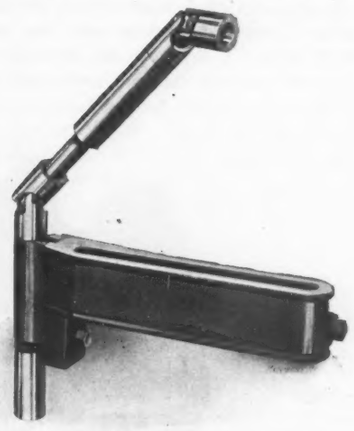
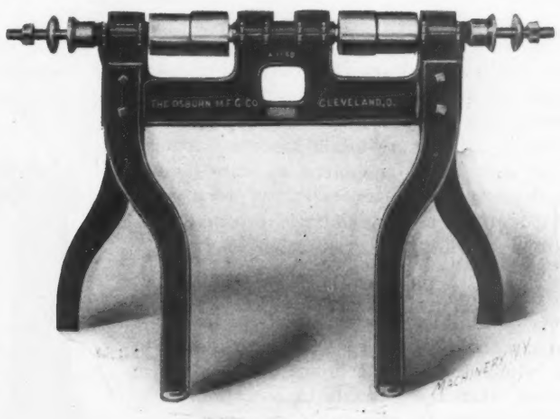


Fig. 2. Spindle and Adjusting Arm of the Fox Multiple-spindle Drilling Machine

OSBORN DOUBLE-SPINDLE GRINDING OR POLISHING MACHINE

The grinder or polisher shown in the accompanying engraving, which is a recent product of the Osborn Mfg. Co., of Cleveland, Ohio, is provided with two independently-driven spindles, so that it is practically two machines in one. This feature makes it possible for two operators to work at the machine at the same time without interfering with each other as the independent drive enables one workman to change his wheel, or to stop the machine for any other purpose, while the man on the opposite side continues his work.

This machine is adapted to the polishing and buffing of large work, and it is especially adapted for the work of the stove manufacturer. It is strongly constructed throughout, and the spindles are of steel and ground. The diameter of the spindles in the bearings is 1½ inch, and the length of the bearings, which are babbitted, is 9 inches. The entire length of both spindles is 62 inches, and the distance from the inside



Osborn Polishing or Grinding Machine with Independently-driven Spindles

of the collars to the extreme ends is 7 inches. The height from the floor to the center of the spindles is 38 inches. Either tight or tight and loose pulleys will be furnished.

As will be noted by referring to the illustration, the front legs bend inward, which not only gives convenient standing room for the workmen, but also increases the rigidity of the machine as a whole. A floor space of 60 by 32 inches is required for this lathe, and its approximate weight, when packed for shipment, is 300 pounds.

BLISS STRAIGHT-SIDED PRESS OF UNUSUAL PROPORTIONS

A straight-sided single-crank press that is of unusual interest because of its great size has recently been built by the E. W. Bliss Co., 5 Adams St., Brooklyn, N. Y. It is the largest press of this type that has been built by this company, and, as far as we know, it is the largest of this type built by any press concern. It shows the continually increasing tendency toward the building of larger and heavier presses for the manufacturing of heavy sheet-metal stampings to replace articles previously made of castings, or for such heavy stampings as were heretofore made by hydraulic presses, the crank press method giving a more uniform production in addition to effecting considerable economy in manufacture.

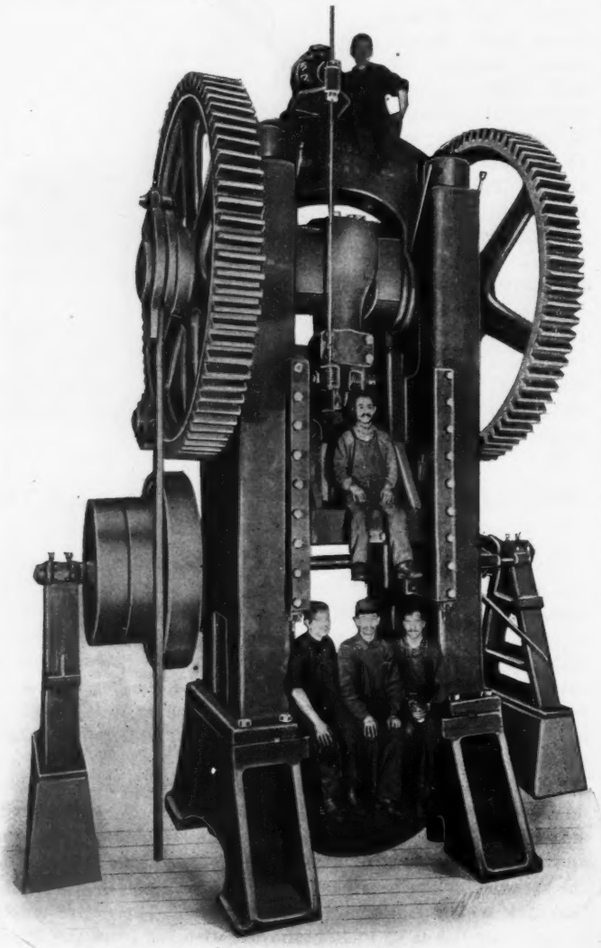


Fig. 1. Front View of Large Bliss Press

Fig. 1 shows a front view of the press, which is of the built-up type construction, in which four large vertical tie-rods receive all the strain and relieve the frame columns of the pressure exerted when the press is in operation. The frame columns are of very large cross-sectional area, imparting great rigidity to the entire press. The crankshaft is 16 inches in diameter and weighs 9500 pounds. Power is transmitted to it at both ends which greatly reduces the torsional strain on the shaft and equalizes the pressure on the journals and gears. The slide, which is guided for practically its entire length in the gibs when the tools are doing their work, is, owing to its great size and weight, raised and lowered by a 4 horsepower motor mounted on top of the press, as shown. The power is transmitted from the motor to the worm and the worm-wheel adjustment through a vertical shaft.

Fig. 2 shows the rear of the press and gives a good idea of the gearing. The machine is triple geared and the entire train is made up of cut steel gears and pinions. The large main gears each weigh about 13,000 pounds.

This press is controlled by a hand lever operating a powerful friction clutch of a new type, designed especially for heavy duty. By means of this clutch the machine is always under instant control, and it may be stopped and started at any part of the stroke. Attached to the wheel is a safety coupling, which acts as a safety guard in case the press, through carelessness or otherwise, is subjected to a pressure greatly in excess of that for which it is designed. The total weight of the press is 190,000 pounds.

MANVILLE AUTOMATIC SWAGING MACHINE

A swaging machine recently brought out by The Manville Brothers Co., Waterbury, Conn., is shown in the accompanying engraving. This machine has a full automatic feeding and cutting-off mechanism for handling such work as bicycle spokes and similar articles. The swager proper is the same as that found on the well-known rotary machines now on the market, the work being done by a series of rolls mounted in a cage rotating at high speed. The wire enters this machine through the double roll straightener shown to the right, passes through the hollow spindle in the center of the swager, and through the feed grip and cut-off quill at the extreme left where the wires are cut off to the proper length and dropped.

The main swaging spindle is driven by a belt on a heavy pulley fastened to the rear end of the spindle. The other mechanism is driven by the pulley, worm shaft and worm

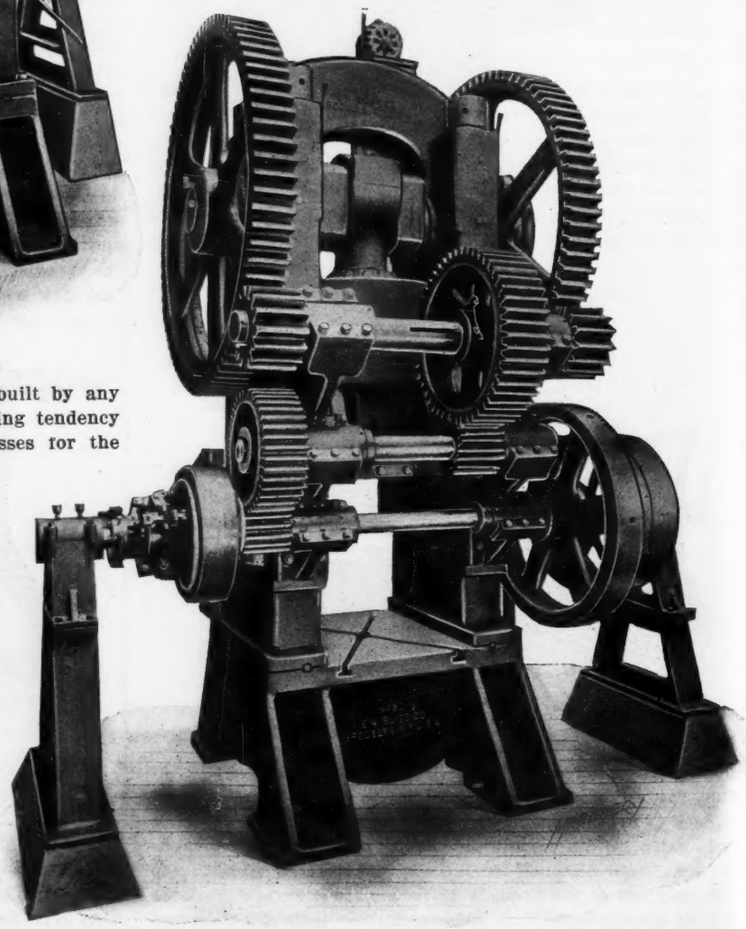
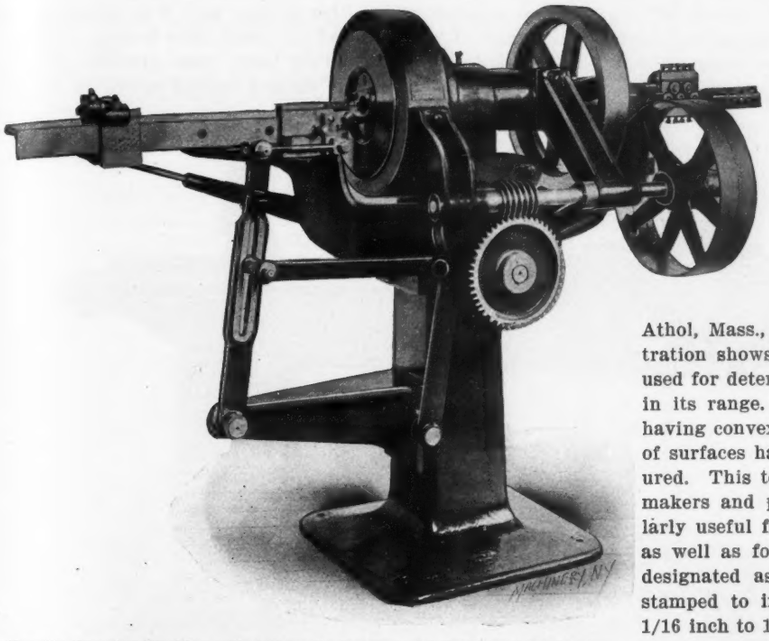


Fig. 2. Rear View of the Bliss Press

shown, which meshes with a worm-wheel on the main camshaft passing through the pedestal. This shaft carries four cams which operate, respectively, the feed, cut-off, binder and die-controlling mechanism.

The feed consists of a short lever with a roll engaging the

large feed cam; a link connecting this lever with the long, slotted lever, shown to the left; and an adjustable link connecting the slotted lever to the feed grip lever, mounted on a slide which travels back and forth on a dovetailed slide way. The length of the swaged portion of the wire is regulated by adjusting the horizontal link in the vertical slotted lever. The length of the unswaged portion depends upon the throw of a cam-piece set into the main feed cam, different pieces being set in for different work.



Manville Swaging Machine with Automatic Feeding and Cutting-off Mechanism

The cut-off mechanism consists of a forked connection having a roll engaging the cut-off cam, this connection terminating in a threaded rod passing through a swivel on the end of a swinging lever. This lever carries a miter segment meshing with a corresponding one on the horizontal lever shown, which carries the cut-off knife. These short levers, knife, etc., are mounted on a casting which is adjustably clamped on the same dovetailed slide way that carries the feed slide. It will thus be seen that the bracket and its immediate mechanism, may be adjusted for cutting shorter or longer wires.

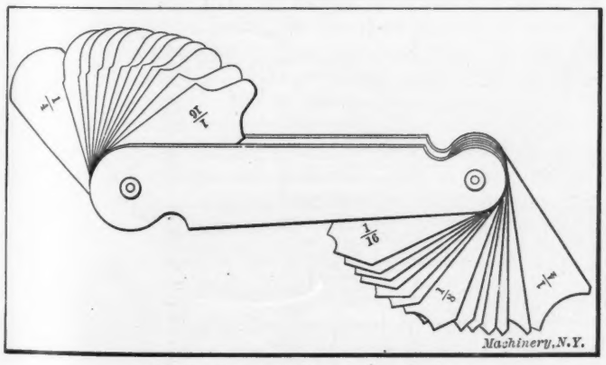


Fig. 1. Starrett Fillet or Radius Gage

The binder which holds the wire in place while the feed grip is returning for another stroke, consists of a lever with a roll engaging the binder cam within the pedestal, and having a set-screw adjustment at its outer end. This screw operates upon a vertical rod, which it forces against the wire at the top of the bracket carrying the straightener.

The die-controlling mechanism consists of a lever at the rear of the machine, which carries a roll, engaging a cam on the main shaft. This lever has a vertical member, carrying a second roll, which operates between the two flanges of a grooved collar adjustably mounted on a hollow spindle extending through the center of the main swaging spindle. On the forward end of this hollow spindle are hinged two wedges which are free to reciprocate between the swaging dies and the backing pieces which take the thrust of the swaging rolls. When the hollow spindle with its wedges is thrust forward, the dies are closed upon the wire and are swaging; when drawn back, the wire is left unswaged and of its full original diameter.

With this machine a great variety of work may be accomplished, with a minimum of labor cost, as the wire can be taken directly from the coil, straightened, swaged, cut to length, and dropped out complete without handling.

STARRETT RADIUS GAGE AND PLIERS

Recent additions to the line of small tools manufactured by the L. S. Starrett Company, Athol, Mass., are shown in Figs. 1 and 2. The first illustration shows a radius gage that, as the name implies, is used for determining the radius of any curved surface within its range. There are two sets of leaves or gages, one having convex and the other concave ends so that the radii of surfaces having either of these formations can be measured. This tool is adapted for the use of machinists, toolmakers and patternmakers, and it will be found particularly useful for laying out special forming tools, dies, etc., as well as for measuring fillets. It is made in two sizes designated as A and B. Size A has 26 leaves that are stamped to indicate the radii which vary by 64ths from 1/16 inch to 1/4 inch. Size B is made with 32 leaves which are also stamped to show the radii which vary by 64ths from 17/64 inch to 1/2 inch.

Fig. 2 shows a pair of pliers which, as the engraving indicates, have a wide range of adjustment. The lower jaw may be moved in or out by turning the knurled worm shown which engages a rack cut on one side of the jaw. The handles are pivoted to each other and move together so that they are always the right distance apart to grip with the hand. The jaws have a capacity for pieces ranging from 0 to 1¼ inch, and they can be adjusted to grip evenly either a straight or taper surface. As the pivoted jaw has a short fulcrum, the pliers have considerable gripping power. They are made from drop forged steel with handles struck up from heavy stock to give ample strength for all requirements.

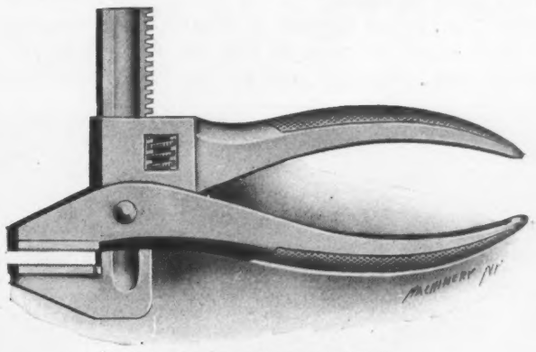


Fig. 2. Starrett Expansion Pliers

SCHELLENBACH GEARED HEAD LATHE

The John B. Morris Machine Tool Company, Cincinnati, Ohio, is now manufacturing the design of Schellenbach geared head lathe, shown in Fig. 1, which illustrates the standard 16 inch by 8-foot lathe arranged with what is known as a semi-quick-change gear-box. This gear-box is made to interchange with the quick-change screw-cutting attachment, and either the semi-quick-change gear-box or the quick-change screw-cutting attachment may be applied at any time after the lathe leaves the factory, should a change be desired. The semi-quick-change gear-box provides three changes of feed for every

change of gears, and, as will be noted by referring to the illustration, the change-gear quadrant is mounted upon and swings directly from the gear-box, thus permitting this part to be manufactured as an independent unit.

The apron feed is through a splined screw and a steel sliding double bevel pinion. Both cross and longitudinal feeds are driven through frictions and are reversible in the apron. A positive feed is provided which permits of the use of the rack for rough chasing all screw pitches shown in the index, thereby relieving the lead-screw of excessive wear. Means are provided for disengaging the rack pinion from the rack, and there is also an adjustment of the rack pinion to compensate for wear. The eccentric lever at the right end of the apron enables the operator to lock the carriage to the bed for facing. The chasing indicator is located at the right end of the carriage and is made so that its worm-wheel may be swung out of engagement with the threads of the lead-screw when not in use. The apron handwheel, as well as that of the tailstock, is counterbalanced. The steady-rest is arranged to be faced in either direction.

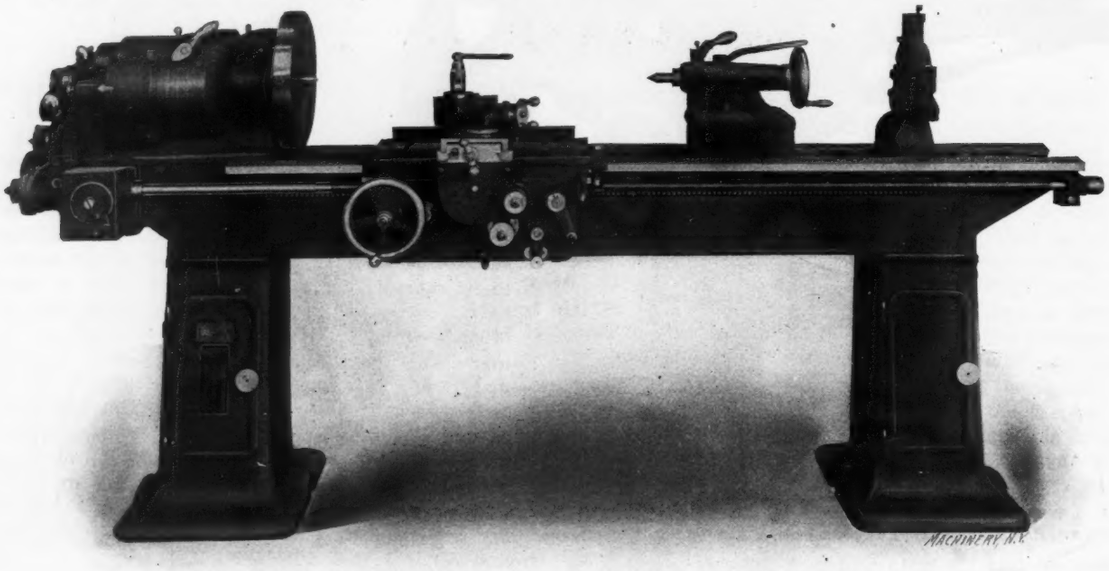


Fig. 1. Latest Design of Schellenbach Geared Head Lathe

Fig. 2 shows a sectional plan and an end elevation of the geared headstock, and a sectional view of the friction for driving the spindle when the back gears are not used is shown to the extreme right in this illustration. The driving pulley *A* is keyed to a bronze sleeve which bears directly upon the lathe spindle. This bronze sleeve has a hardened nickel steel pinion *B* keyed to it, the outside diameter of which is the same as that of the bronze sleeve referred to. Splined to slide upon this bronze sleeve and pinion *B*, is the hardened nickel steel cone gear *C*, the longitudinal movement of which is controlled by the handle *D* on shaft *E*, sector *F* and sliding fork *G*. The desired longitudinal position of cone gear *C* is determined by the pointer of handle *D* and the index plate located just below it, as shown in Fig. 1. This index plate provides a list of diameters to be turned at various cutting speeds in feet per minute and these diameters correspond, of course, to the various gear combinations of the driving train. The range of speeds and diameters given on this plate is indicated by the table Fig. 3. The four vertical columns of the index plate correspond with the four longitudinal positions of the cone gear *C* which is shown in the illustration at its farthest position to the left, thus exposing the pinion *B* and allowing one of the rocker-gears *H* to be meshed with it. The second and third positions of cone gear *C* to the right bring these cone gears into proper alignment with the rocker-gears *H* the pinions of which mesh with internal gear ring *M*. The fourth or last position of cone gear *C* to the right clutches it positively to sleeve *I* which revolves loosely upon the lathe spin-

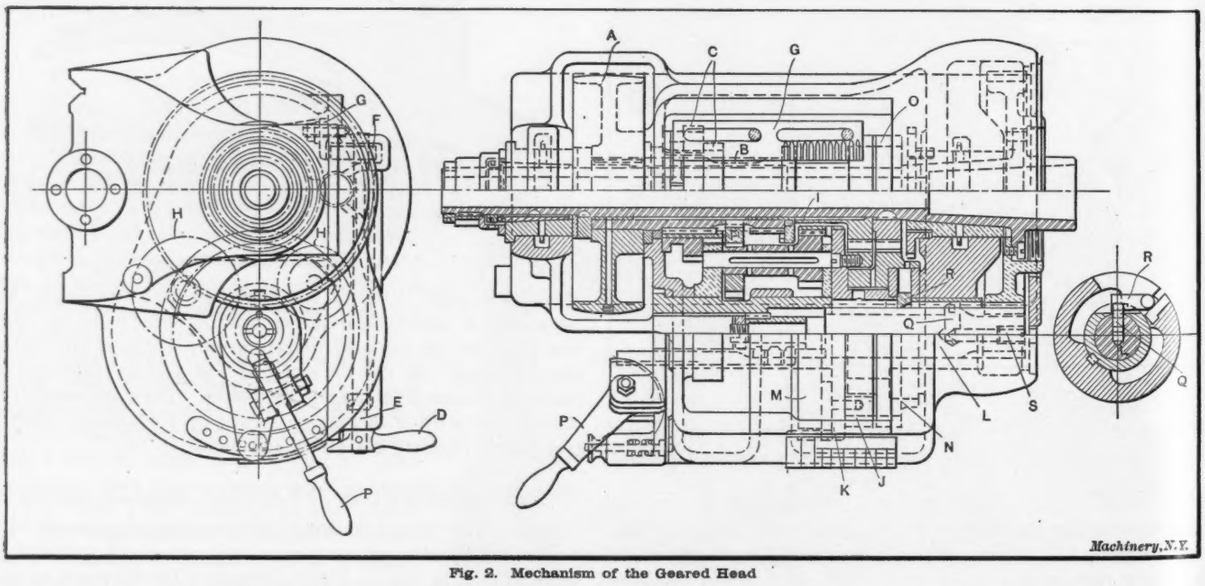


Fig. 2. Mechanism of the Geared Head

dle. The clutch teeth on sleeve *I* are made to receive the teeth of the small gear of the cone *C*. Sleeve *I* has a gear formed upon it and this gear meshes with gear *J* which is doweled and screwed to flanged casting *K*. Flange *K* is splined to main driving pinion *L* and carries the internal gear ring *M* previously referred to. Flange *K* also drives the friction ring shown in section to the right, and this ring locks gear *N* to gear *J* by the longitudinal movement of driving pinion *L* through rack and lever *P* seen at the left end of the headstock housing. Gear *N* meshes with gear *O* which is keyed to the spindle, and it has the same number of teeth as the loosely mounted gear *I;* thus when cone gear *C* is clutched to gear *I* and gears *J* and *N* are locked together by the friction ring, the spindle will be driven at its maximum speed which is the driving pulley speed. When the lever *P* is moved to the left, the friction becomes disengaged and the pinion *L* slides on and engages the steel face gear mounted on the outside of the front spindle bearing; the drive is then positive. The friction is operated by a dog or plug *Q* in pinion *L*, and this plug engages the lever *R* in the friction. Adjustment of this friction is provided by the screw *S* which may be adjusted from the front of the headstock.

Cutting Speed in Feet per Min.	Position for Back Gear Lever	The Schellenbach Lathe, Patented Feb. 19, 1907; May 4, 1909							
		Lever	Dia.	Lever	Dia.	Lever	Dia.	Lever	Dia.
30	Left	Down	12	Down	9	Down	6 1/16	Central	2 9/16
		Up	5 1/4	Up	4 1/16	Up	2 1/16		
	Right	Down	1 9/16	Down	1 3/16	Down	7/8	Central	9/32
		Up	11/16	Up	1/2	Up	3/8		
40	Left	Down	15 15/16	Down	11 3/16	Down	8 15/16	Central	2 15/16
		Up	7	Up	5 7/16	Up	3 15/16		
	Right	Down	2 3/8	Down	1 9/16	Down	1 3/16	Central	3/8
		Up	15/16	Up	11/16	Up	1/2		
50	Left	Down	20	Down	15	Down	11 3/16	Central	3 5/8
		Up	8 3/4	Up	6 3/4	Up	4 15/16		
	Right	Down	2 5/8	Down	1 15/16	Down	1 7/16	Central	15/32
		Up	1 3/16	Up	7/8	Up	5/8		
60	Left	Down	23 15/16	Down	17 7/8	Down	13 3/8	Central	4 7/16
		Up	10 9/16	Up	8 1/8	Up	5 15/16		
	Right	Down	3 1/8	Down	2 5/16	Down	1 3/4	Central	9/16
		Up	1 3/8	Up	1 1/16	Up	3/4		
70	Left	Down	27 7/8	Down	20 7/8	Down	15 5/8	Central	5 1/16
		Up	12 5/16	Up	9 1/2	Up	6 7/8		
	Right	Down	3 5/8	Down	2 3/4	Down	2 1/16	Central	11/16
		Up	1 5/8	Up	1 3/16	Up	15/16		
80	Left	Down	31 7/8	Down	23 7/8	Down	17 7/8	Central	5 13/16
		Up	14 1/16	Up	10 13/16	Up	7 7/8		
	Right	Down	4 3/16	Down	3 1/8	Down	2 3/8	Central	3/4
		Up	1 7/8	Up	1 3/8	Up	1 1/16		

Fig. 3. Diameters of Work and Cutting Speeds given on Headstock Index Plate

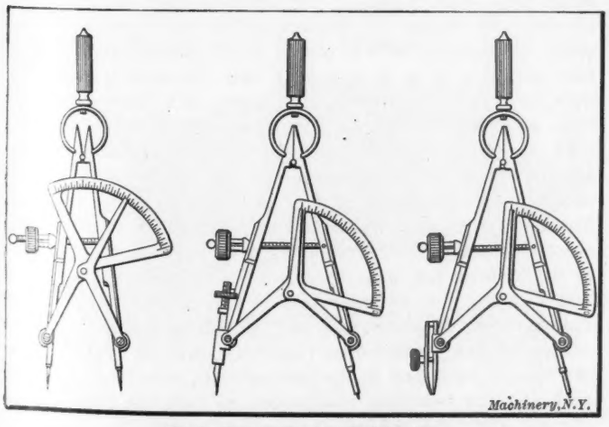


Fig. 1. Bows with Attached Scales

When cone gears *C* are disengaged from the clutch of gear *I*, the rocker-gears *H* may be engaged to the selected gear of the cone. The end elevation shows the two rocker-gears *H* and the method of mounting them upon the rocker casting. When the drive is through the cone gear *C* to either of the rocker-gears *H*, it is transmitted to the spindle either through gears *N* and *O* or through pinion *L* and the face gear. The headstock, as shown, provides fourteen changes of speed, running the driving pulley at a constant speed.

This design permits of an oil bath for the gears, and all of the gears which are thrown in and out of engagement are made of nickel steel and are hardened. All speed changes, whether in back gear or out of back gear, may be made while the machine is running. There are no loose gears and no gears are exposed. When providing this machine with a motor drive, a bracket is mounted upon the headstock and a gear is provided in place of the pulley *A*. The lathe is also arranged so that the drive may be obtained with a silent chain driven from a motor mounted underneath the headstock. This style of headstock is also applied to the 18- and 20 inch lathes.

"PRESTO-SET" BOWS FOR DRAFTSMEN

A unique form of draftsman's bow, in the divider, pencil, and pen types, is illustrated in Fig. 1. This bow has a graduated arc or scale attached to it and an indicating point which shows the radius to which the instrument is set. This feature eliminates the inconvenience of using an ordinary scale and effects a considerable saving in time. The scale on the instrument is graduated to read in thirty-seconds of an inch and each instrument is carefully adjusted before leaving the factory. The graduations are larger than actual size and therefore easily read. When making adjustments, no spinning of the nut is necessary, as a shifting and self-clamping type of adjusting nut is provided, so that the instrument can be quickly set to any radius within its range. When making adjustments, the legs are pressed slightly together to release the nut, after which they are opened or closed until the pointer is approximately over the desired graduation. The nut is then placed in position with the right hand and turned until the instrument is accurately set as determined by the scale. With a little practice this type of bow can be set with ease and rapidity. It is claimed that these instruments will maintain their accuracy indefinitely, though it is, of course, essential that the lengthwise adjustment of the needle points be not disturbed. The pencil point, which is continually wearing away is provided with a special screw adjustment, as shown, so that it can be lengthened after sharpening. These instruments are furnished either single or in combination of two or three and with or without a case. They are the product of the Eugene Dietzgen Co., Chicago and New York.

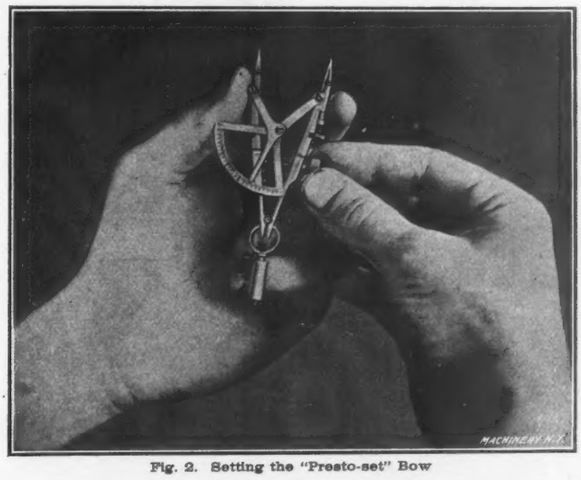
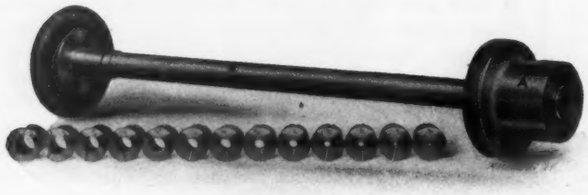


Fig. 2. Setting the "Presto-set" Bow

LATHE DRAW-IN ATTACHMENT AND SPRING COLLETS

The accompanying half-tone shows a draw-in attachment and spring collets made by The John B. Morris Machine Tool Company, of Cincinnati, Ohio. This attachment may be applied to the lathes built by this company. The set of collets shown are for the 14-inch lathe, and on this particular size the holes in the collets range from ⅛ inch to 1 inch and vary by sixteenths. The bore of chuck *A* fits the nose of the lathe spindle, and the threads on the periphery of the chuck, screw directly into the face gear which is mounted outside of the front spindle bearing. A hardened and ground tool-steel ring is forced into a counterbore in the front end of chuck *A* and

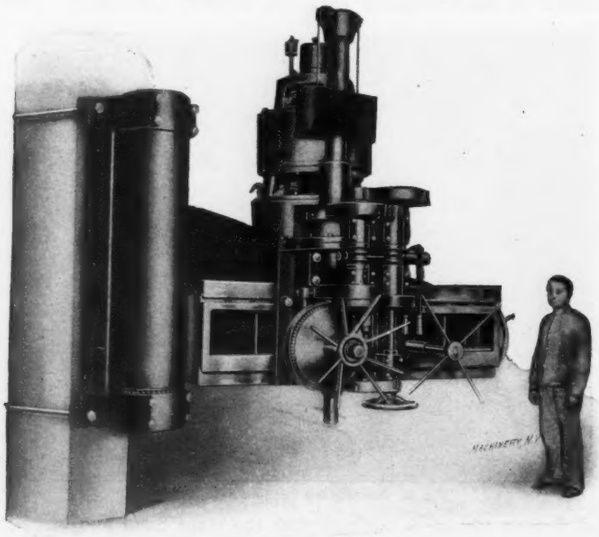


Lathe Draw-in Attachment and Collets

this ring receives the tapers of the collets. The collets are tightened on the stock by the tube *B* which extends through the spindle and has a hard-wood handwheel keyed to it, as shown. The collets are secured from turning by a bushing fitted into the spindle taper, which contains in its bore a key receiving the keyseats of the collets. This device is supplied as an extra attachment and on all sizes of the lathes built by this company. The larger machines, of course, permit the use of larger sizes of collets, than those here shown.

DETRICK & HARVEY HEAVY-DUTY RADIAL DRILL

A powerful radial drill that may be attached to the cross-head of a gantry, or to a heavy building column, as shown in the illustration, has been brought out by the Detrick & Harvey Machine Company, of Baltimore, Md. The spindle of this machine is driven by a vertical type, variable speed motor



Large Radial Drilling Arm that may be attached to a Building Column, etc.

giving spindle speeds ranging from 100 to 400 revolutions per minute. The motor is mounted on the drilling head and it drives the spindle direct through spur-gearing having a ratio of one to four, giving practically the full output of the motor to the spindle. This direct drive has been found economical from the standpoint of power, as it eliminates the multiplicity of gearing and transmission parts found in standard radial drills.

The spindle of this drill is 3½ inches in diameter, and it has a vertical movement of 18 inches that may be effected by hand or power. There are four changes of power feed varying from 0.0076 inch to 0.0625 inch per revolution of the spindle. The radial arm is of box shape construction and it has a vertical face 24¾ inches wide. It is heavily braced to a cylindrical vertical portion which rests upon a ball-bearing seat in a pivot bracket. The vertical bearings provided at the top and bottom are equipped with roller bearings. The minimum and maximum radial drilling capacities of this machine are, respectively, 2 feet 6 inches and 6 feet 6 inches, though this capacity can be increased if desired. The weight of this drill complete with the motor as illustrated, is 16,000 pounds.

BRISTOL'S COMPENSATED RECORDING THERMOMETER

The recording thermometers manufactured by the Bristol Co., of Waterbury, Conn., have been constructed in various different forms, depending for their operation on the expansion of a liquid, the expansion of the vapor of a liquid, or the expansion of a gas. These thermometers have been used extensively for ranges of thermometers up to 800 degrees F., but the models equipped with flexible connecting tubes between the sensitive bulb and recording instrument and depending for their operation on the expansion of a vapor or a gas, have not, until recently, been adapted for recording the lower ranges of temperatures.

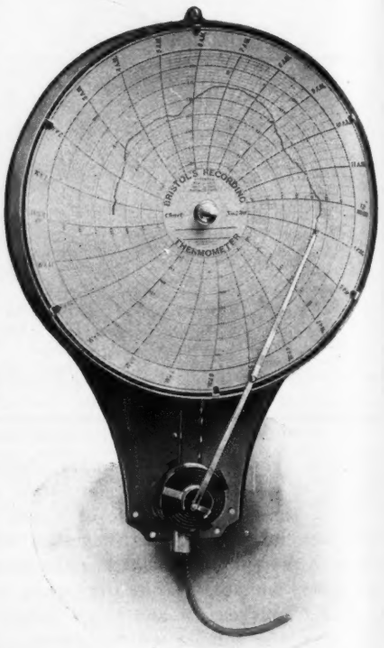


Fig. 1. Bristol Gas-filled, Class III, Recording Thermometer — Case removed to show Interior Mechanism

A new compensated gas-filled recording thermometer, has recently been developed by the Bristol Co., for recording comparatively low temperatures, such as the temperature of the atmosphere, of water, or of brine in refrigeration systems, etc. The important new feature of this thermometer is the patented compensating attachment with which it is equipped, that automatically corrects any changes of temperature in the recording instrument. A sensitive bulb is placed in the element the temperature of which is to be measured, and this bulb is connected with the pressure tube of the instrument by a flexible capillary tube, as shown in Fig. 1, which is a view of the instrument with the case removed to show the interior mechanism. The sensitive bulb, the flexible connecting tube, and the spiral pressure tube are all filled with an inert gas under pressure. The changes of temperature in the element surrounding the sensitive bulb cause corresponding changes in the pressure of the confined gas, and these pressure changes are measured and recorded by the instrument. The sensitive bulb is ordinarily about 10 inches long and ¾ inch in diameter, and the volume of gas contained in it is very large in proportion to the volume contained in the fine capillary tube connecting the bulb and the recording instrument, so that the error due to changes along the connecting tube are negligible.

It has long been recognized that an air or gas thermometer is the ideal type for measuring low temperatures, provided such an instrument can be used in the laboratory where it is

possible to make the various corrections. It is in this connection that the value of the compensating attachment for the spiral pressure tube, with which this new instrument is equipped, is apparent as it causes the same readings or records when the temperature at the recording instrument changes as it would if the temperature at the instrument remained constant. The need for such a compensator can be illustrated by considering the application of a thermometer of this type, for recording the temperature of brine in a refrigeration system. The temperature of the atmosphere at the point where the recording instrument was installed might, of course, change, although the temperature of the brine at the point where the sensitive bulb was installed might remain constant; in such a case, the thermometer, inasmuch as it is used

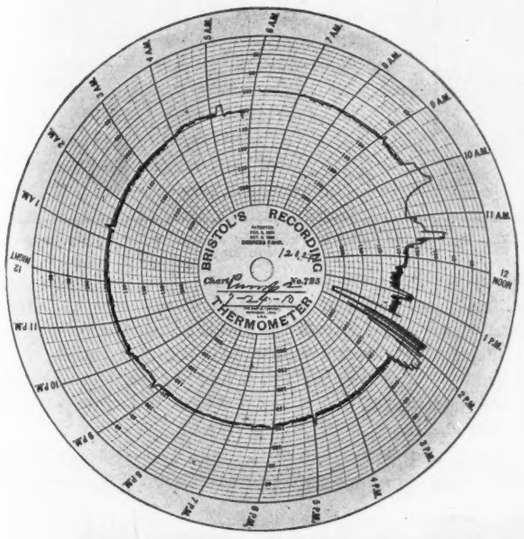


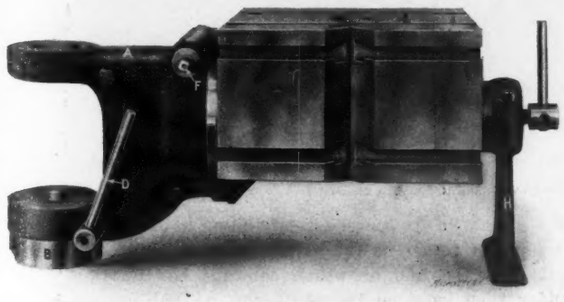
Fig. 2. Chart giving Record of Condenser Water Temperatures

to record brine temperatures should be so constructed that it would be effected only by the temperature changes at the sensitive bulb.

Fig. 2 shows a record of condenser water temperatures as recorded by one of these thermometers on a chart having a range of from 40 to 220 degrees Fahrenheit. It will be noted that this chart has a reversed scale of uniform graduations, the temperature increasing toward the center. For condenser water temperatures, the reversed scale is a desirable feature, as the average temperature is usually lower than 125 degrees, whereas the temperature is likely to reach the boiling point occasionally when the vacuum in the condenser is lost, as shown by the record made between 1:30 and 1:45 P. M. on the chart illustrated.

WORM SWIVELING TABLE FOR MORRIS RADIAL DRILL

A worm swiveling table that is supplied as an attachment to the line of plain radial drills manufactured by the John B.

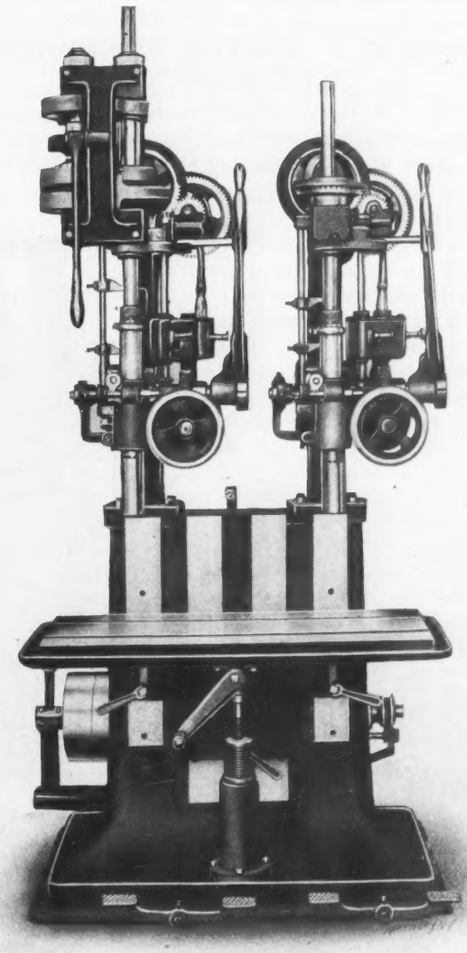


Swiveling Table Attachment for Morris Radial Drills

Morris Machine Tool Company of Cincinnati, Ohio, is shown in the accompanying engraving. The upper lug of the forked-shaped casting *A* is bored to fit onto, and is supported by, the lower end of the column of the radial drill. The lower end of *A* is supported on the plug *B* which is doweled and bolted to the base of the machine in correct alignment with the column. That portion of casting *A* which bears upon the column of the radial and on plug *B*, is made in halves and is bolted together and the stud and lever *D* clamp *A* from swinging with the column. The box table *E* swivels upon *A* and is adjusted by a worm formed upon *F*, which worm engages a worm-wheel secured to the box table. A circular portion of the table is graduated from both sides of zero to 90 degrees. This swiveling table has a V planed in one side for convenience in clamping cylindrical work, and the top of the table is bored in the center to receive a circular revolving table when this is required. The swiveling table may be securely locked, after being set, by the clamp-handle shown to the right. The stand *H* bears upon the base of the machine and prevents the outer end of the table from deflecting when heavy strains are imposed upon it. This table is furnished with the 2½-, 3-, and 3½-foot radial drills manufactured by this company.

SUPERIOR 22½-INCH AUTOMATIC HIGH-SPEED DRILL

An interesting development in drilling machinery is illustrated herewith. This machine, which is a 22½-inch size and fully automatic in its operation, is a recent addition to the



Automatic High-speed Drilling Machine, built by the Superior Machine Tool Co.

line of upright drills manufactured by the Superior Machine Tool Co., Kokomo, Indiana. It is designed to handle high-speed steel drills and it has a tapping capacity for machine or pipe taps up to 1½ inch.

As the illustration shows, the left-hand spindle is equipped with a tapping attachment. The machine can be set to drill

to any depth up to 8 inches, and by means of adjustable dogs, the spindle can be automatically tripped at any predetermined point, after which it backs out and goes forward again in about one-tenth of a second; in other words it takes about that long for the spindle to come out, return to its original position, and start downward. By adjusting a set-screw in the trip lever, the spindle can be made to feed downward, automatically trip itself, and run back to its upper position and stop; it may then be started downward by the throwing of a lever that is operated from the front of the machine.

This drilling machine has positive geared feeds, and all gears are heat treated and ground. The spindles have ball thrust bearings and the sleeves are graduated. The table, which is of the knee type construction, is heavy and rigid. It is raised and lowered with a telescoping screw, and it has a working surface of 40 by 17 inches. The machine can be started or stopped by a shifter lever, or each spindle can be controlled independently by the two foot pedals shown in the front of the base. All operating levers are so positioned that they may be controlled without the workman changing his position. The face width and diameter of the tight and loose pulleys is 4¼ by 10 inches, and the three-stepped cone pulleys are designed for a 3-inch belt. This machine is built in several different styles, having from one to four spindles. Either the wheel-and-lever plain type with or without back gears, or a wheel-and-lever, back geared, power-fed machine with automatic stops, can be provided.

DETRICK & HARVEY HEAVY-DUTY PLANER

The Detrick & Harvey Machine Company of Baltimore, Md., has added to its line of planers the design of heavy-duty forge planer shown in Fig. 1. This machine is of the beltless type, it being driven by a 50 horsepower motor which transmits the power through a Wheeling Mold & Foundry Co. induction clutch reversing drive. By means of this drive, cutting speeds ranging from 35 to 50 feet per minute, and return speeds varying from 65 to 100 feet per minute are obtained. Provision is also made for changing the cutting and return speeds quickly and independently of each other.

This planer, while a 48-inch pattern, has a maximum capacity for work 50 inches wide and 48 inches high. The table, which has one flat and one V way, is 43 inches wide and 12 inches deep over the ways. The bed is 22 inches deep, and it has three vertical webs of metal which insure rigidity. The housings, which are secured at the top by a tie-piece extending from the front to the rear, are of rectangular box shape and have faces 16¼ inches wide. The cheeks for the housings have a vertical depth of 32 inches and are 55 inches long. The cross-rail, which is raised and lowered by an independent motor, has a vertical face of 19 inches and a depth of 20 inches between the housings. The tool-heads are of extra heavy pattern and have steel aprons and holders. All gearing is of steel, cut from the solid, except the driving worm (the Sellers drive being employed) which is made of phosphor bronze. This driving worm has six teeth in engagement with the table rack, which has a 9-inch face and is cut from solid forged bars.

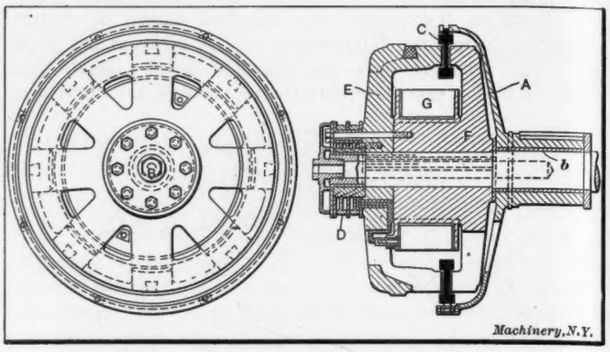


Fig. 2. Induction Clutch which operates on the Principle of the Induction Motor

In Fig. 2 a section of one of the induction clutches is shown, for the benefit for those not familiar with this type of drive. This clutch, in its operation, is similar to an induction motor. The copper ring *C* is the driven member and it is held by a spider *A*, the hub of which contains the bushing *b*. This spider runs loose on the shaft and its hub carries a pinion through which power is transmitted. All the other parts shown belong to the driving member which is keyed to the continuously-running motor shaft. This driving member, which acts also as a flywheel, consists of the two-part steel casting *E* and *F*, the coil *G* and the collector rings *D*. The

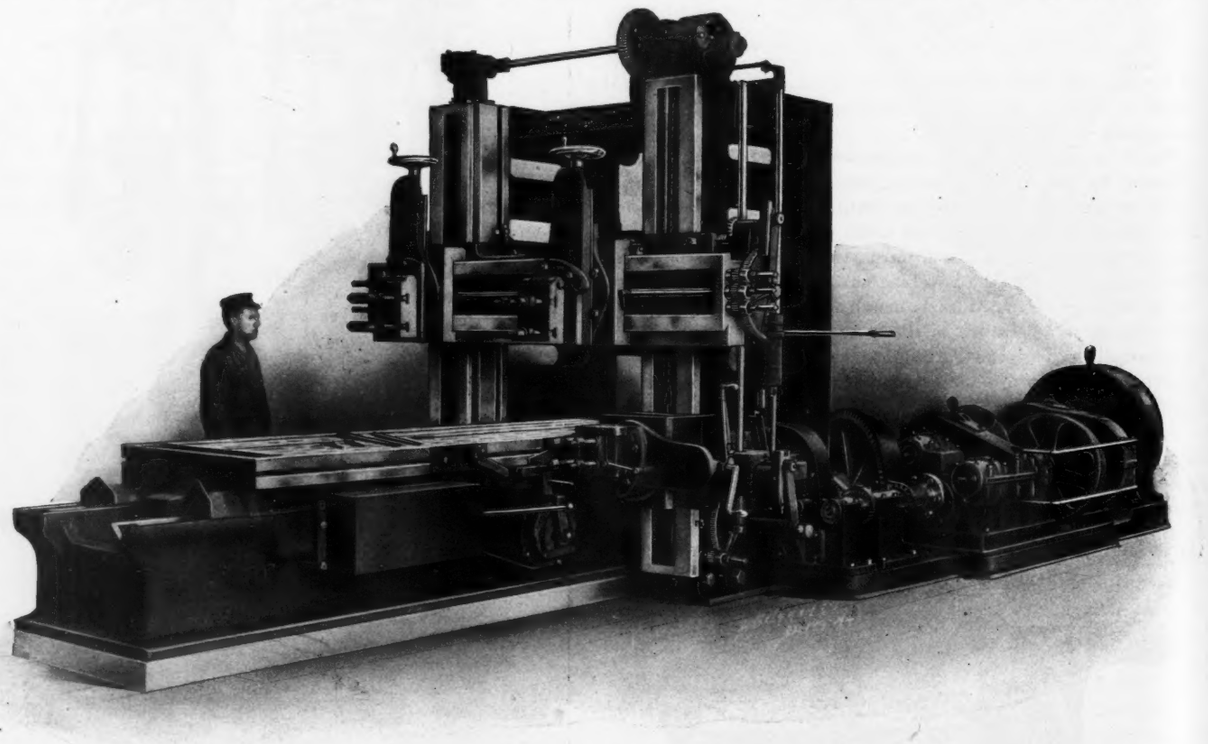


Fig. 1. Detrick & Harvey Heavy-duty Planer with Induction Clu ch Drive

copper ring *C* has running clearance between castings *E* and *F*, and since it is non-magnetic, it has no tendency to be drawn over towards the poles on either side. This ring has, however, a high conductivity and because of this fact and its position with relation to the revolving magnetic driving member, it is pulled along by this driving member on the same principle as that of the induction motor. Two of these clutches are employed, one for the cutting and the other for the return stroke, and a switch worked by dogs admits a small current to one clutch on the cutting stroke and to the other clutch on the return stroke. It will be seen that the induction clutch transmits power without contact between its driving and driven members.

The weight of this planer, exclusive of the motor and induction drive, is 53,000 pounds, and some of the weights of the principal parts are as follows: Table, 9100 pounds; bed, 14,500 pounds; each housing, 9300 pounds; cross-rail, 3800 pounds; each cross-rail head, 1400 pounds; each side head, 1300 pounds.

This planer can also be furnished for a belt drive direct from the line-shaft or, if desired, it can be driven by a belt-connected motor.

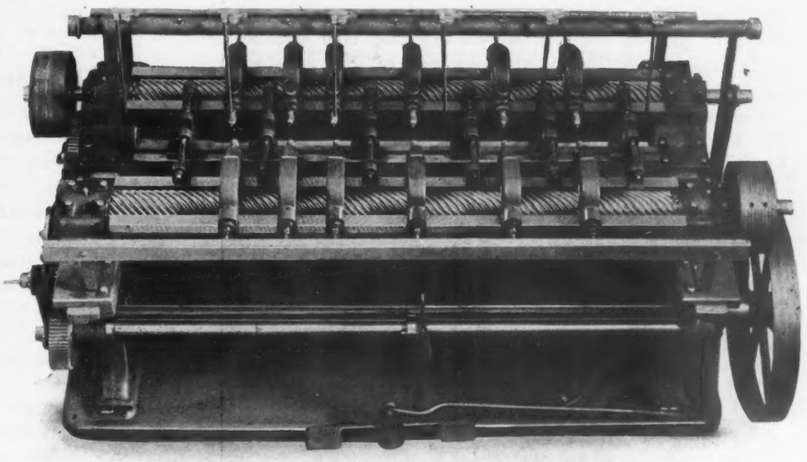


Fig. 2. Front and Top View of the Duplex Drilling Machine

MOLINE SPECIAL DUPLEX DRILLING MACHINE

The duplex drilling machine shown in the accompanying halftones is intended, principally, for drilling pipe and also for bar drilling when the holes are so closely spaced that they cannot be drilled at one setting. When drilling pipes with a machine of the ordinary type, there are several difficulties: One is the time lost when the drill is passing from one wall of the pipe to the other; another is the breakage of drills, caused either by fins or burrs or the striking of the drill against the further wall; and the large burr made when the drill comes through, has also been an undesirable feature. In addition, it has been impossible to use short drills owing to the lengths required when the drill had to pass through both the guide bushing and the pipe.

Fig. 1. Multiple-spindle Duplex Pipe and Bar Drilling Machine, built by the Moline Tool Co.

With this new duplex type of machine, which is a recent design built by the Moline Tool Company, Moline, Ill., these difficulties have been overcome. As the illustrations indicate, the pipe is drilled from each side, thus eliminating the time required for feeding the drill through the hole of the pipe, and the burrs are all on the inside where they are not, as a rule, objectionable. The breakage of drills is prevented in two ways: The drill does not go through and strike the opposite wall of the pipe where practically all breakage occurs, and, in addition, a hollow spindle, a special chuck, and a straight grooved drill are used, the latter projecting beyond the chuck just far enough to pierce one of the pipe walls. The drill is positively driven by the jaws of the chuck and it is kept from slipping by a threaded rod shown in Fig. 3. By supporting the drill close to the point, drill bushings or guides are not needed and special jigs, bushings, etc., for different sizes of drills are unnecessary.

The pipe is held in adjustable V-blocks and it is clamped by plunger-rods which are connected to the rails. These blocks and plunger-rods may be readily removed, if it is desired to use any other type of jig. The heads are adjustable anywhere along the rails and they have the spiral drive regularly employed by this company. The spindles have ball-thrust bearings, and means are provided to compensate for wear. The feed is obtained by causing the rails to approach and recede from each other, and, under ordinary circumstances, this movement should be continuous, the number of strokes being so timed that the operator can remove and replace the work while the plungers which hold it are withdrawn. An automatic stop is provided, however, which will disengage the feed at the back end of the stroke. The feed can be thrown in or out at any point by the double-ended foot treadle shown.

This machine is furnished complete with a pump, tank and piping, and requires practically no special appliances for any work within its capacity. It is built in several sizes, capable of driving drills from 3/16 inch up, and any number of heads are provided.

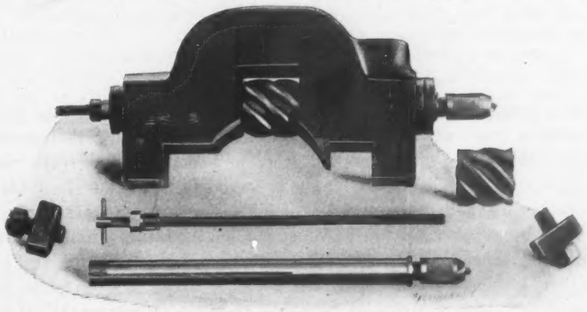


Fig. 3. Spindle Head and Details

TURRET AND TURRET SLIDE FOR MORRIS LATHES

A turret that can be applied to the carriage of the engine lathes built by The John B. Morris Machine Tool Company, Cincinnati, Ohio, is shown in Fig. 1, and in Fig. 2 a turret slide is illustrated which is also applicable to the various sizes of lathes built by this company.

The turret, Fig. 1, is made interchangeable with the compound rest and it contains a bronze nut that engages the cross-feed screw of the carriage. A bracket is provided which can be bolted to the back of the carriage and this bracket has an adjustable stop-screw that serves as a positive stop for the turret. The locking-pin, which is of tool steel, is controlled by the lever *A* and this pin engages a hardened tool-steel

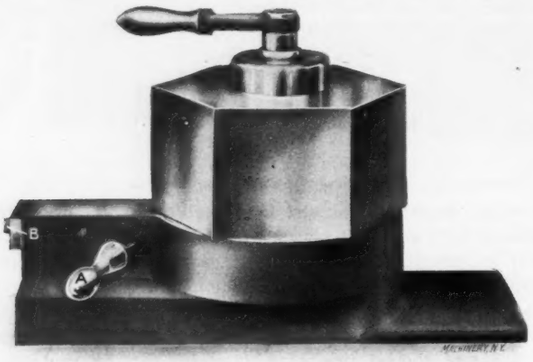


Fig. 1. Turret for Carriage of Lathes built by the John B. Morris Machine Tool Co.

indexing ring. The wear of the locking pin is taken up by a taper gib that is adjusted by screw *B*. The flats on the turret, which is hexagon in shape, measure 9 by 5 inches and holes up to 2¼ inches in diameter may be bored.

The turret and slide shown in Fig. 2 is without power feed, the movement of the slide being by hand through a pilot shaft and pinion in the ordinary manner. The hexagon turret itself is revolved and locked automatically or by hand, as desired. Provision is made for disengaging the devices for automatically revolving the turret, when it is to be operated by hand.

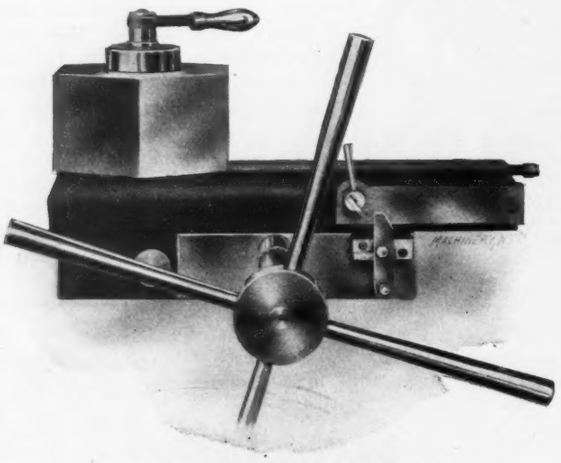


Fig. 2. Turret and Slide for Morris Lathes

This turret slide is also supplied with power feed and an automatic stop, and when arranged in this way a gear box is secured to it. This attached gear box contains a train of gears, the driven one of which is keyed to the pilot shaft the driving gear being splined to the lead-screw. This arrangement gives as many rates of speed as there are changes for feeding or screw cutting. The automatic stop is always supplied with the power feed, and in such cases the top slide is equipped with a T-slot at *B* which receives an adjustable stop dog. This dog operates a latch which disconnects the gear feed train previously referred to. The particular turret slide illustrated is for a 16-inch lathe. It has a 9-inch traverse when revolved automatically, and a 12-inch traverse when operated by hand. The turret will clear tools which do not exceed 5½ inches in diameter.

LOXON REFLECTOR LAMP GUARD

The McGill Manufacturing Company, of Valparaiso, Indiana, is now manufacturing the improved form of electric guard, illustrated herewith, which is especially adapted for use around machinery. As the engraving shows, this is a combined guard and reflector so that it not only gives protection to the lamp, but enables light to be reflected at any given point. This reflector is also useful as a shade for protecting the workman's eyes, particularly on machine tool lights, and its usefulness in this connection, as well as a reflector and guard, will doubtless appeal to machinists in general. The guard is locked on the socket of the lamp with a key, so that the lamp is not only protected from breakage, but from petty theft, as the guard cannot be removed without considerable difficulty, unless the key is employed. Another advantage claimed for this guard is that it enables the use of smaller lamps than would ordinarily be necessary, thus reducing the light bills.

Combined Lamp Guard and Reflector for the Shop

NEW MACHINERY AND TOOLS NOTES

Ellipsograph: J. T. Kelley, West Rush, N. Y. Instrument for drawing ellipses, which enables ellipses covering a wide range of axes to be drawn. A compass forming a part of the ellipsograph, may be detached, when desired, and used as ordinary dividers.

Combination Pliers: Medhus-Pihl Co., Hastings, Mich. Combination pliers having double-ended jaws for regular plier work and for cutting. The jaws have a square recess fitting a projection of similar shape on the handles which enables the jaws to be placed in four different positions with relation to the handle, thus adapting the tool to a variety of uses.

Molding Machine: Union Foundry & Machine Co., Pittsburg, Pa. Molding machine of the combined jar and squeezing type. It is adapted for making light castings, such as are made in snap flasks, and also deep and heavy castings. When making deep molds, the squeezing head is pushed back and the machine converted into one of the jarring type.

Vernier Caliper and Depth Gage: Schuchardt & Schutte, Cedar and West Sts., New York. Combination vernier caliper and depth gage so designed that the inside jaws and depth gage are simultaneously set to coincide with the outside measurements. The tool has two sets of graduations which, by means of verniers, give minimum readings of 1/128 inch and 0.001 inch, respectively.

Thread Gage: William Avery & Co., Foxboro, Mass. Thread gage with attachment for setting an internal threading tool after grinding. This gage has an end which fits the partly finished thread, and a V-groove near the other end by which the tool is set. As this V-groove is located just one inch from the end that fits the thread, the tool will "pick up" the partly finished thread, provided it is not fractional.

Welding Outfit: Alton, Laine & Co., Long Island City, N. Y. Oxy-acetylene welding outfit comprising oxygen and acetylene storage tanks, with keys and valves; oxygen and acetylene reducing regulators with two gages each; oxygen safety device; acetylene safety and purifying device; welding torch with 10 tips; 24 feet of high-pressure hose; and one pair of Hallau chemical-ray goggles, and the required wrenches.

Screw-Driver: Kinckiner & Scott, 626 North 12th St., Philadelphia, Pa. Screw-driver having blades of 3-, 6- and 8-inch lengths which interchange with a brass mahogany-covered handle. These blades are of tool steel and have a tempered cross-pin which engages a slot in the end of the handle to take the torsional strain. The handle end of the blade is threaded to fit the cap-nut which retains it in position.

Combination Shear: McSherry Mfg. Co., 122 Ninth St., Pittsburg, Pa. Combination shear, punch, and bending press adapted for cutting, punching, and bending rounds, squares, flats or angles. This tool is hand operated, and it will punch a 5/16-inch hole through 1/4-inch steel; shear 1/4 by 2-inch steel, or ½ inch rounds; and bend ¼ by 2-inch steel. Interchangeable punches and dies are furnished which adapt this tool to a wide variety of work.

Oil Furnace: Bellevue Furnace Co., Detroit, Mich. Fuel-oil muffle furnace for high-speed steel, in which the flame is conveyed from the inlet to the furnace outlet through a continuous spiral groove formed in the brick lining. The muffle itself is supported by the spiral remaining between these grooves. When steels which cannot be safely treated in a horizontal furnace, are to be heated, the furnace can be easily changed to a vertical position.

Valve Grinder: J. F. Higbee, Muncie, Ind. Machine for grinding gas-engine or other valves mechanically. The valve being ground is given a progressive rotary movement combined with an occasional vertical movement to allow new grit to enter the seat. The cylinder castings are placed on the machine base and the valves to be ground are connected with the spindles. It is claimed that one man, with this machine, can grind from four to eight valves in 10 or 12 minutes.

Thread Milling Attachment: Garvin Machine Co., Spring and Varick Sts., New York City. Thread milling attachment for milling machines, adapted to cut either single or multiple threads within a wide range. The milling cutter is mounted on the face of the column and is driven by the spindle, while the work holder is placed on the table and is rotated through change gears. This attachment has been used successfully for threading such work as milling machine and lathe spindles and similar parts.

Double Spindle Milling Machine: Beaman & Smith Co., Providence, R. I. Double, vertical-spindle milling machine with minimum and maximum adjustments between spindle centers of 24 and 40 inches, respectively. Adjustable supports are attached to the housings on either side for steadying the lower ends of the cutter spindles. The table is 36 by 48 inches and it has a travel of 52 inches. The housings are 46 inches apart, and the spindles have a vertical adjustment of from 3 to 9 inches above the table. Two conveniently located levers control the nine available feed changes.

Rotary Cleaner: Brown Hoisting Machinery Co., Cleveland, Ohio. Rotary cleaner for removing rust and scale from structural material, etc. It consists of two disks mounted on a hub and containing near their peripheries a series of pins upon which are carried a large number of steel blades or cutters. These blades are rectangular in shape and the holes by which they are supported on the pins, are elongated so that the blades have considerable freedom of movement. This tool is directly driven by a high-speed pneumatic or electric grinder, and its effectiveness is due to the chipping action of the rapidly revolving blades.

Vertical Boring Milling Head: J. Morton Poole Co., Wilmington, Del. Boring, drilling, milling, and tapping head for the vertical boring mill. This head will take milling cutters up to 12 inches in diameter, and it is driven either by a 5 horsepower variable speed reversing motor, or by a two-speed countershaft and a three-step cone pulley. There are 12 spindle speeds ranging from 8 to 96 revolutions per minute; 4 boring feeds varying from 1/64 to 1/8 inch per revolution of the spindle; and a similar number of milling feeds varying from 1/80 to 1/10 inch per revolution of the spindle. This head has the same number of feeds for facing and turning as the standard type.

Horizontal Boring, Drilling and Milling Machine: Franklin Machinery Co., Franklin, Pa. Horizontal boring, drilling and milling machine equipped with an overhead steady-bar in addition to an outboard bearing, for use when a long span is necessary. The drive of this machine is of the all geared type, giving twelve speed changes. There are six changes of feed. Both the drive and feed gears are immersed in oil. The automatic feed may be applied to the boring-bar saddle, the outboard bearing, or the table in both directions. The maximum distance from the bar to the table is 36 inches; there is a continuous feed for the bar of 36 inches, and the horizontal capacity is 72 inches.

Multiple Spindle Drilling Machine: Langelier Mfg. Co., Providence, R. I. Special multiple-spindle drilling machine and three drill heads containing 16, 24 and 44 spindles, respectively. The main spindle of this machine is driven by a quarter-turn belt connecting with a driving pulley at the rear. A stepped cone provides three speed changes which are sufficient for the drill combinations used. The work is fed by raising the table by means of a large pilot wheel connected through reducing gears with the rack-and-pinion movement. The table has a working surface of 18 by 26 inches, and a vertical adjustment of 4½ inches. It slides in a knee that can be adjusted and fastened in different positions.

Friction Clutch: Hilliard Clutch & Machine Co., Elmira, N. Y. New type of friction clutch in which the two friction plates are drawn against the friction ring by screws that are operated through spiral gears and racks attached to the sliding collar. The friction ring contains a number of hard-wood inserts and when these are worn, adjustments to compensate for wear may be easily made. One of the advantages claimed for this clutch is that the friction may be gradually applied and the load "picked up" smoothly and without any sudden shock. This feature adapts the clutch to delicate machinery, such as is found in textile mills, but it is also used with satisfactory results on large machine tools.

Crank Shaper: C. S. Dodge, Lowell, Mass. Twenty-four inch heavy-duty crank shaper, having V-shaped ram guides to insure accurate alignment. The ram is actuated by a back-geared crank with a quick return. Changes in the stroke can be instantly made with the machine in motion or at rest, and the length of the stroke is indicated by a stationary index. The feed-screw is provided with a dial, reading to thousandths. The table, which is of the box form, can be swiveled to any angle so that either of its sides may be used. This table can also be removed when it is desired to attach work directly to the apron. The column is so designed that shafts up to four inches in diameter may be passed under the ram for keyseating.

Sheet Metal and Wire Reels: Baird Machine Co., Oakville, Conn. Wire reels for wire forming machines or presses, and sheet metal reels also adapted to press work. The sheet metal and scrap reels are adjustable so that coils of varying inside diameters can be quickly accommodated; the outer flange is also adjustable for different widths of metal. These reels are interchangeable on the stud or shaft so that in case it is necessary to run the metal through the press a second time, the empty metal reel and the scrap reel can be interchanged, thus saving considerable time. The wire reels also have adjustable arms, the ends of which turn inward so as to catch the loose inner coils of wire and force them into place as the coils are placed on the reel.

Roller-Jaw Drill Chuck: Weaver Manufacturing Co., Springfield, Ill. Drill chuck composed principally of a heavy outer rim or shell on the inner wall of which there are three cam faces, against which a similar number of hardened steel rolls operate. These rolls are contained in a cage that may be rotated by means of a key, thus causing the rolls, as they ascend the cam surfaces, to grip the drill shank at three points 120 degrees apart. With this construction, the resistance of the drill to turning and the grip, increase simultaneously, as the resistance causes the hardened roller jaws to move further along the cam surfaces so that they are automatically tightened. This chuck is simple in construction, and it is claimed that it will not mar or injure the drill shank, no matter how severe the strain may be.

Trolley Wheel Lathe: Garvin Machine Co., Spring and Varick Sts., New York. Lathe especially equipped for rapid production of trolley wheels for electric railways. The grooves in these wheels, which are made from material varying from hard-bronze to pure copper, are finished by two tools mounted on the cross-slide, each of which forms half the groove. These tools are fed nearly to the bottom of the groove without touching the metal; then by a sudden movement of the carriage to the right and left, they are made to remove the hard scale without the wear on the cutting edge that would take place if they were fed in slowly by means of the cross-feed. The work while being machined is held in a Garvin pneumatically-operated chuck. With this machine a hard-bronze wheel 4 inches in diameter can be finished in 2 minutes.

Metal Sawing Machine: Taylor-Shantz Co., 230 Mill St., Rochester, N. Y. No. 2 metal-sawing machine designed to meet the demand for an accurate and rapid cutting-off tool for light work. The construction is simple and compact. The drive to the saw is through cut bevel gears, a large worm, and a hobbed worm-wheel, all of which are pack-hardened to insure long life. The feed is by gravity, there being a lever and an adjustable weight which can be moved to different positions as the saw becomes dull, or to adapt the feed to different stock. The vise is of the V-block pattern and the stock is clamped in position by a hardened screw. The saw blade, which is 8 inches in diameter, is made of a special semi-high-speed steel, and it has a constant relief from the rim to the center. This saw runs in an oil bath and the machine is equipped with an adjustable gage.

Power Press: Manville Bros. Co., 27 Benedict St., Waterbury, Conn. New line of single-acting open-back power presses. The frames of these presses are well reinforced

where necessary; the beds are deep; the shaft is of hammered steel; and the slide strong and well braced at the back. At the front and sides of the bed there are finished surfaces for attaching feeds and fixtures. The clutch is of the well known Johnson type, and the press is arranged either to run continuously as long as the treadle is depressed, or, in special cases, it can automatically be thrown out of engagement at each revolution. The friction is a new automatic releasing type which releases as the foot treadle is depressed and is applied with full force as the treadle ascends. These presses are fitted with a side or throat roll feed, friction dial or ratchet dial feed, or any special attachments.

Press: Ferracute Machine Co., Bridgeton, N. J. External notching press for cutting the notches in the peripheries of armature disks. This machine is designed to produce accurate work rapidly. The shaft runs continuously and is connected to the ram by a pitman and a ram clutch. The work is indexed by the direct action of a pawl upon a ratchet which is clamped to a spider, attached to the main spindle. After one revolution of the disk, the ram stops automatically at the top of its stroke, and the pawl is disengaged from its ratchet. This press is adapted for disks varying from 2 to 24 inches in diameter. When operating upon medium sized work having about 20 or more notches, the press makes about 400 strokes per minute, while for large work having comparatively few notches, it may be run at about 200 or 300 strokes per minute. The ram is capable of exerting a pressure of about seven tons. The weight of the machine is 1400 pounds.

Power Hammer: Reliance Engineering & Equipment Co., Milwaukee, Wis. Power hammer adaptable to general forging work. One of the principal features of this hammer is the spring arrangement which makes it unnecessary to adjust the stroke, except in special cases, and gives added momentum to the ram on its downward or working stroke. The arm carrying the hammer head or ram is made in two parts and is pivoted to the frame in the center. This arrangement makes it possible for the arm to adjust itself automatically for widely varying thicknesses of stock without the necessity of hand adjustment and without lessening the force of the blow. As the ram ascends, it has sufficient momentum to compress an elliptic spring, which, in turn, gives back the stored energy for the next blow; as a result the blow is many times heavier than the weight of the ram. When an adjustment of the stroke is necessary, this is made by shifting the position of the crosshead to which the connecting rod is fastened, in or out on its guide. Extending around the base of the hammer there is a semi-circular treadle or foot lever by which the hammer is started and stopped. The speed and force of the blow is also regulated by varying the foot pressure on the treadle. A brake connected with the treadle acts on the flywheel as soon as the treadle is released.

Thread Rolling Machine: The National Machinery Co., Tiffin, Ohio. Vertical thread rolling machine in which long rods can be threaded as well as bolts. The blanks are fed into the dies horizontally, enabling work of any length to be handled. The design is very rigid and occupies a minimum of floor space. As the dies have their grooves in a vertical plane, lubricant may be employed effectively. The reciprocating die-slide has a slow downward stroke and a quick return. This slide is backed by a train of hardened steel rollers actuated by racks and pinions. These rollers reduce wear to a minimum as well as the friction and power for operating. The blank to be threaded is inserted into the gap between the die against a suitable gage, the blank lying upon a rest or feed-bar. A starter actuated by a cam on the main shaft, introduces the blank to the die at the proper time, and the rest or feed-bar automatically returns to its original position to receive the next blank. The movement of the feed-bar is parallel to the faces of the dies which, with the aid given by the starter, insures the blank being introduced into the dies correctly. This machine is built in three sizes having maximum capacities for rolling threads ½ inch in diameter by 4 inches in length; 1 inch in diameter by 3 inches in length; and 2 inches in diameter by 4 inches in length. The intermediate diameters with lengths up to 6 inches can also be rolled.

* * *

MAKER OF MODEL SPRING WINDER

In the department of New Machinery and Tools for December, we illustrated and described a machine for winding springs, but failed to give the name of the manufacturer. This spring winder is the product of the Model Spring Winder Co., Bowling Green, Ohio.

* * *

Phosphor-bronze should not contain too much phosphorus, says the *Brass World*. The tensile strength is greater when it is low in phosphorus, and the castings are generally sounder. For sand castings, from 0.10 to 0.25 per cent of phosphorus may be considered as the maximum.

A MACHINE FOR MAKING BARBED WIRE

Barbed wire of the usual type consists of two No. 12 twisted strands around and between which the barbs are mounted. The recently patented machine described in the following is being introduced by Blashill & Gray, London, Canada, and is ingeniously designed for producing barbed wire for which only one No. 9 wire is used. The barbs, contrary to common practice, are first cut to the required length, afterwards formed in the machine, and finally pressed solidly onto the main wire or strand which has been flattened at intervals to

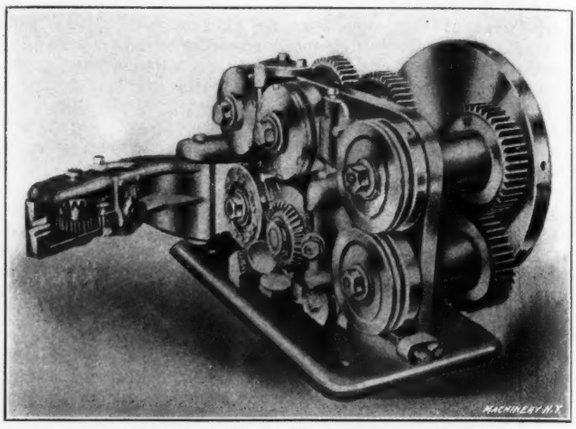


Fig. 1. Machine for Making Single-strand Barbed Wire

form seats for this purpose. The barb itself requires a minimum length of wire. It is made up of one loop only, wrapped around the main wire.

The essential part of the machine for making barbed wire of this type is shown in the half-tone illustrations Figs. 1 and 2, and in the line engravings Figs. 3 to 8, inclusive. The action of the machine is very interesting because of its simplicity and is as follows: The strand of wire passes first between rolls *A* and *B*, Fig. 2. These rolls flatten the wire slightly at the places where barbs are to be seated. From these rolls the wire passes between rolls *C* and *D*, where the barb is fed in and bent over it. The barb-wire feeding

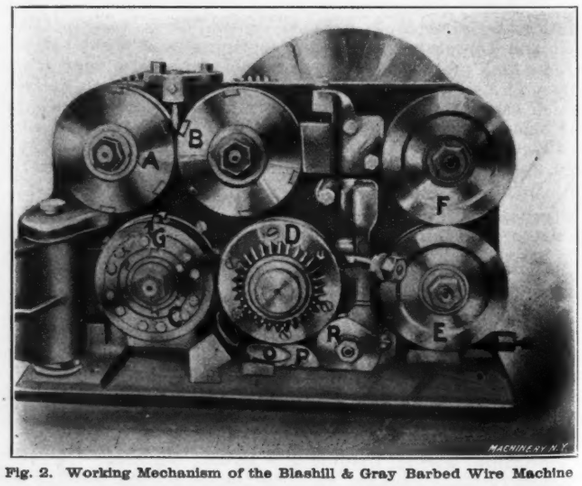
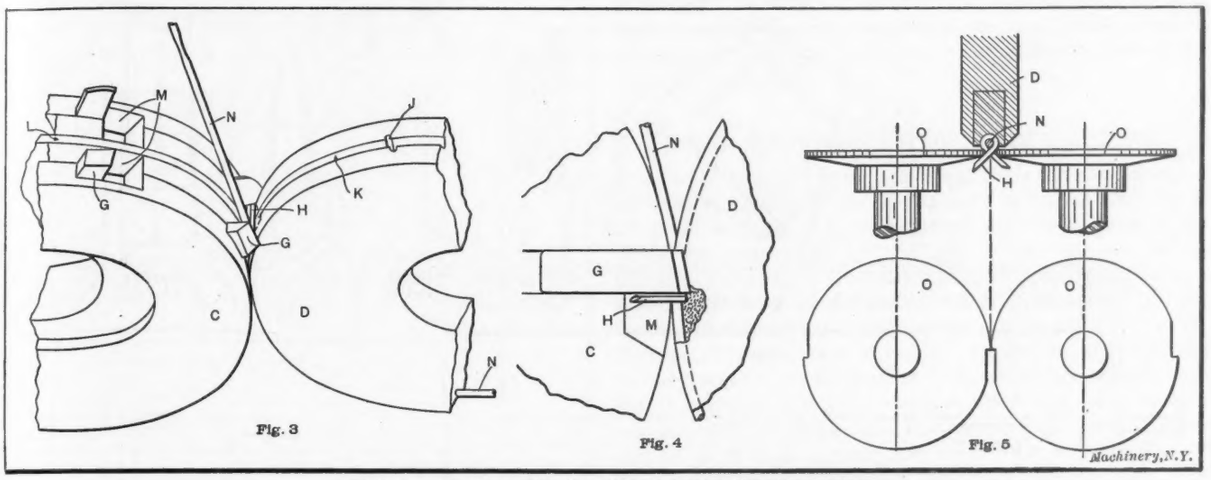


Fig. 2. Working Mechanism of the Blashill & Gray Barbed Wire Machine

mechanism is shown swung back, to give access to the rolls, in Fig. 1. Normally, when the device is in action, this arm closes in over rolls *C* and *D*, forming a guard over the gears as well. The barbs are cut off to the right length by the cutters *G* on roll *C*, shown in Figs. 2 and 3, which act against a stationary cutter on the feed roll arm. The barb *H*, Fig. 3, just cut off and still straight in form, now lies between rolls *C* and *D*, and is then forced by the strand wire into the pocket *J* of roll *D*. The strand wire itself, during this operation, is backed up by tongue *L* in roll *C*, and forced into groove *K* of roll *D*. This causes the barb to assume the form of a staple, pockets *M* in roll *C* being provided to give clearance for the ends of the bent wire.

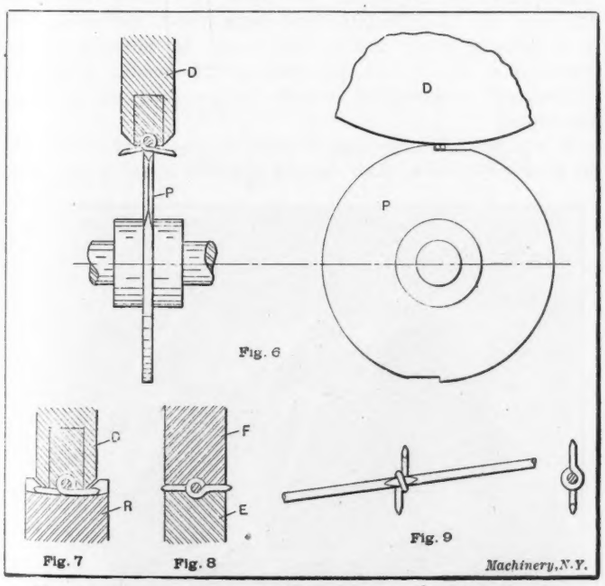
The relative positions of barb, strand wire and rolls, at the end of this operation, are shown in Fig. 4, where the outer plate or ring of roll *C* has been removed, and a portion of the roll *D* broken away to show the cutting tool and staple-shaped barb. The main strand *N* now carries the staple-shaped barbs in the pockets half-way around roll *D*, after which they pass between finishing rolls *E* and *F*. Previously, however, in their passage around roll *D*, the legs of the staple-shaped barbs are crossed by the hard steel disks *O* as shown in Fig. 5. In Fig. 6 is shown a thin hard steel disk *P* which



Figs. 3, 4 and 5. Successive Operations in Barbed Wire Manufacture

spreads the points of the barb further, while the roll *R*, acting against roll *D*, as is partly shown in section in Fig. 7, completes the wrap. Now the finishing rolls *E* and *F* press the barbs solidly on the flattened spot on the strands, as shown in Fig. 8, the whole operation being effected by a simple continuous motion, no reciprocating or oscillating parts whatever being employed. The finished barb on its wire is shown in Fig. 9.

The form of the finished barb is an important feature in this development. It will be seen that the barb is pressed until



Figs. 6 to 9. Final Operations of Manufacture and Finished Product

the points extend radially, from the center. The mechanism is very simple, and it is possible to operate it at a high rate of speed. Several advantages are gained by the method employed. It is possible to use large hard drawn No. 9 gage wire in place of two No. 12 strands, as commonly used in barbed wire manufacture. In this way the total surface to be galvanized is reduced, and the annealing is made easier. The output of the machine is also greater than that of a machine for twisting the strands, while the initial cost, maintenance and floor space are less.

MODERN GRINDING METHODS

In a paper on "Modern Grinding Methods," read before the American Society of Mechanical Engineers at the December meeting, by Mr. B. M. W. Hanson, of the Pratt & Whitney Co., Hartford, Conn., special reference was made to the large-size vertical surface grinder just completed by this company. Surface grinders have usually been made with the wheel grinding on its periphery, but in this machine the ordinary cylindrical wheel has been replaced by a cup-shaped wheel which covers the whole width of the work at once. Water for lubrication and cooling is forced through the center of the spindle, the centrifugal force throwing the water outward and compelling it to pass between the work and the wheel. The table of the machine has a stroke of 6 feet and can grind a flat piece of work 6 feet long and 25 inches wide. The cup-wheel has a diameter of 30 inches, and the whole machine is driven from a single belt by a forty-horsepower motor. As this machine has just recently been built, its capacity has not been fully tested out as yet, but it is interesting to note the results already obtained. In one of the trials, a surface of cast iron 6 feet long and 20 inches wide was reduced 0.010 inch in thickness in five minutes, leaving an excellent finish and a high degree of accuracy. In fact, when tested, no point on the surface was out of true more than 0.0005 inch.

The chips are cut by the outer edge of the wheel when it passes over the work in the same manner as chips are produced by the outer edge of an end milling cutter. The large surface of the wheel in contact with the work simply smooths the surface. It is likely that for some kinds of work having large flat surfaces this method of finishing will prove superior to any other method. It was stated that at the present time it is safe to say that grinding machines have been fully developed to the limit of the cutting capacity of grinding wheels, and that there probably will be no essential changes in grinding methods or grinding machinery until the grinding wheel itself has reached a higher development.

At the present time the difficulty met with in grinding lies in the fact that wheels supposed to be made to the same specifications vary considerably, and the feeds of the grinding machine to be used for different materials must be regulated by the operator not only to suit the material being ground, but also to suit the wheel used. In this respect he cannot always go by previous experience, but must run the machine a few minutes, in each case, to determine the proper feed.

* * *

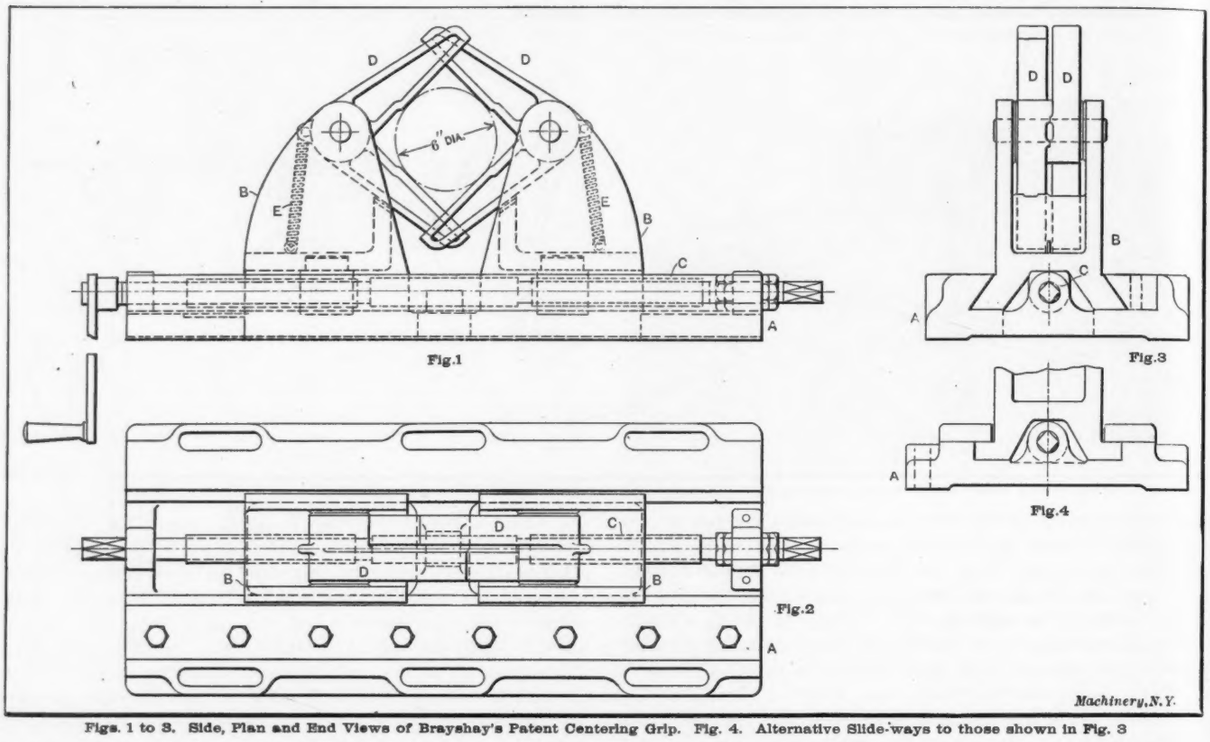
The methods followed by the leading machine tool builders in the manufacture of lathes, planers, drilling machines, etc., have been minutely described in the technical press, but comparatively nothing has been published on the repairing of machine tools. What is the best plan of rebuilding an engine lathe? a milling machine? a shaper? Some one in these United States must have the experience and ability to write and illustrate what he knows. Where is he?

BRAYSHAY'S PATENT CENTERING GRIP

By JOSEPH G. HORNER*

Messrs. Pickerings, Ltd., whose works at Stockton-on-Tees, England, are devoted to the manufacture of lifts, hoists, cranes and similar appliances, have brought out a useful device intended for holding work for boring, drilling, facing, planing, etc. It constitutes a species of large self-centering chuck, adapted for gripping hoisting barrels or drums, pipes, and similar work. When so held the object is automatically centered, so that boring or other operations may be commenced without further setting. No clamping bolts or plates are needed, which feature saves considerable time.

The line-cuts Figs. 1 to 3 show the construction of the grip. There is a base *A*, in which slide two brackets *B*, caused to approach or recede from each other by a right- and left-hand screw *C*, provided with a square at each end for a ratchet wrench. Brass nuts are attached to the under side of the brackets to receive the screws. Fig. 4 shows alternative slideways to those in Fig. 3. Pivoted at the top of each bracket is a cast-steel arm *D*, the gripping faces of which are at an angle of 90 degrees with each other. The arms are so arranged that they can pass each other to grip work of the smallest diameter within their capacity, which is 6 inches. By drawing apart the brackets *B*, diameters up to 15 inches may be gripped.



Figs. 1 to 3. Side, Plan and End Views of Brayshay's Patent Centering Grip. Fig. 4. Alternative Slide-ways to those shown in Fig. 3

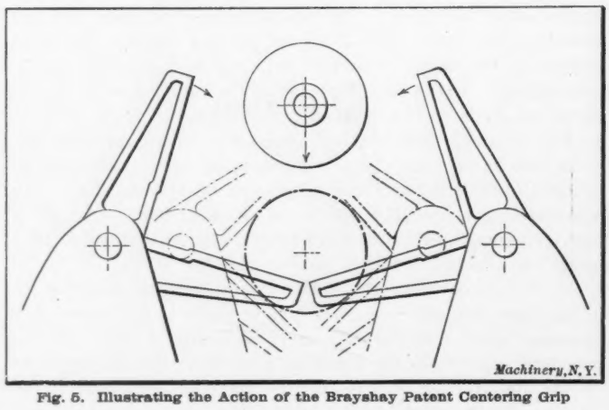


Fig. 5. Illustrating the Action of the Brayshay Patent Centering Grip

The method of introducing the work forms an ingenious feature of the design; it will be seen on referring to Fig. 1 that there are strong spiral springs, *E*, anchored to the brackets and to the back of the arm bosses. The purpose of these is to pull the arms around so that they turn upward and thus free the work, or leave an opening for the introduction of another piece. The diagram Fig. 5, shows the brackets drawn apart and the arms turned upward to receive the drum which is being lowered down into them. As it is lowered, the arms gradually accommodate themselves to its contour, whether round, elliptical, or square, and then by turning the screw, the arms are brought into close contact with the work until it is gripped firmly and concentrically, as indicated by the dotted lines, Fig. 5. In this drawing the amount of opening is purposely exaggerated beyond that necessary to introduce the drum.

It will be understood that a pair of these grips is required to deal with work, their lateral distance apart being regulated by the nature of the work. In the half-tone, Fig. 6, two grips of slightly different pattern are seen, for work up to 2 feet 6 inches in diameter. The screws are operated by ratchet levers, and an auxiliary tie-bolt fastens the top ends of the arms. It may be mentioned that Messrs. Pickerings have supplied a large number of these grips to pipe makers.

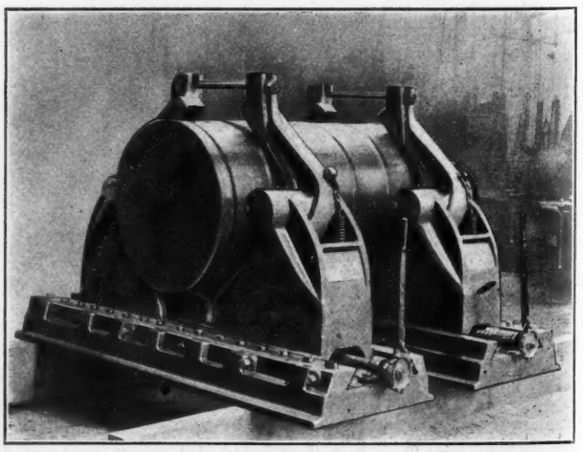


Fig. 6. Brayshay's Patent Centering Grips in Actual Use. The Grips here shown are of Slightly Different Pattern to those described

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MULTIPLE PUNCH PRESS

In U. S. patent No. 977,362 (November 29, 1910), obtained by Thomas A. Banning, Jr., Chicago, Ill., there is an interesting development of the multiple punch press for punching, in conformity with a prescribed plan, by a templet previously prepared in accordance with the arrangement of holes desired in the final product.

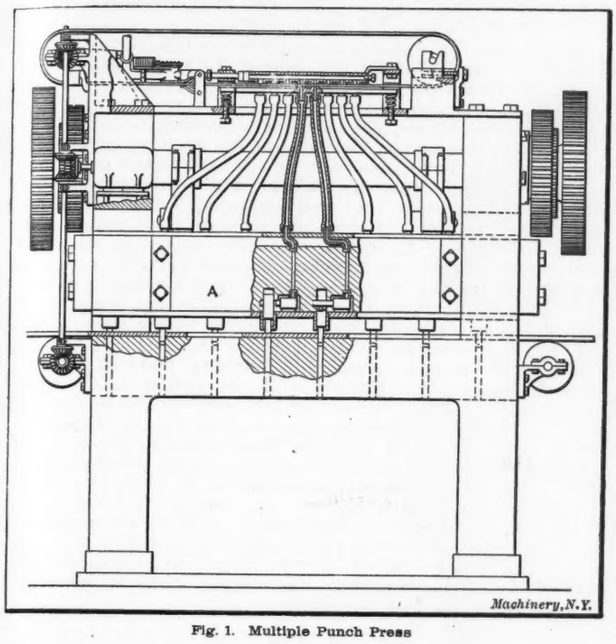


Fig. 1. Multiple Punch Press

Figs. 1 to 3 show the different features of the invention. A movable head *A* carries several rows of punches *B* which register with dies in the stationary bed below. These punches are attached to small plungers *C*. To one side of the individual plunger is a small cylinder *D* containing piston *E*, normally kept to its rear end by a spring. Air pressure from

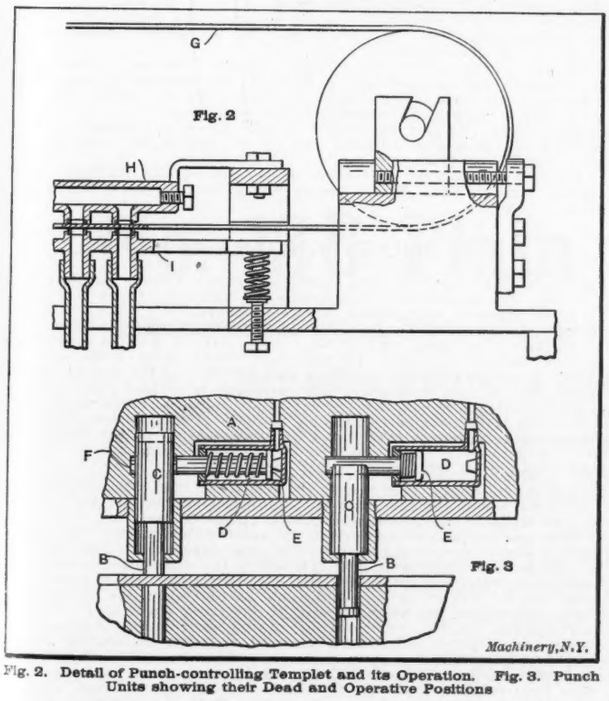


Fig. 2. Detail of Punch-controlling Templet and its Operation. Fig. 3. Punch Units showing their Dead and Operative Positions

above, controlled as hereinafter described, forces the piston forward at the proper time, its piston-rod entering recess *F*, forming a stop for the punch, the plunger for which has a formed bearing at the top to receive it. In its normal position, as shown to the left, Fig. 3, plunger *C* slides up and down and does not punch, whereas the punch to the right is in position to operate.

The control from above is shown in Fig. 2, where *G* is the previously mentioned templet passing over end drums. *H* is an air header under pressure, which pressure passes down to the punches when the templet holes register as shown by the right-hand hole. *H* is rigid, and a tight working air connection is maintained by having *I* floating on a spring as shown. Between the movable punches and this stationary part are flexible hose connections.

The various parts are controlled by electrical means, the whole being automatic, semi-automatic or manually operated, as desired. In addition, the machine is so arranged as to be made workable in units, separately, for small work, these individual units being connected from a central control for handling large parts.

* * *

LOW EFFICIENCY OF UNIVERSITIES

Morris Llewellyn Cooke, member of the American Society of Mechanical Engineers and an exponent of higher efficiency in all fields of labor, has investigated the workings of a few American universities and colleges at the instance of the Carnegie Foundation. His findings have been published in a bulletin issued by the Carnegie Foundation December 19. Mr. Cooke investigated the Universities of Harvard, Columbia, Toronto, Wisconsin and Princeton, Haverford and Williams Colleges and the Massachusetts Institute of Technology. The report indicates that great waste of effort and loose methods are prevalent in nearly all. Useless research work is being carried on at great expense and other work is being done of no practical value. Gardeners and other laborers start work at nine o'clock in the morning and the educational work is suspended for athletic events, etc. Mr. Cooke found the administration of Columbia University to be on a higher plane than any of the others investigated.

* * *

MAKING HARDENED TRY-SQUARES

A task is difficult in proportion to our inexperience. What is very difficult for a machinist may be easy for a toolmaker, and *vice versa*. So when we say the making of a knife edge straightedge probably is one of the most difficult jobs required of a toolmaker, we mean a toolmaker not having special experience in that work. If the knife-edge straightedge is secured at right angles to a hardened steel stock to make a precision try-square, the job is increasingly difficult—for the inexperienced, and most of us are in the inexperienced class. A reader has expressed his desire to see a detailed description of the process of making hardened try-squares. Is there another reader of MACHINERY experienced in making them who can clearly describe and illustrate the work? An article on this subject no doubt would interest toolmakers as well as machinists.

* * *

According to *Page's Weekly* a machine tool builders association is in course of formation in Great Britain. A meeting of the machine tool trade was held in Manchester on November 4. Among forty or fifty influential firms who have already promised membership are Alfred Herbert, Ltd., C. W. Burton, Griffiths & Co., H. W. Ward & Co., Ltd., C. Redman & Sons, Pheil & Co., Geo. Richards & Co., Ltd., Chas. Churchill & Co., Ltd., Wm. Asquith, Ltd., Pollock, Pollock & Macnab, Ltd., and J. Parkinson & Son. It was made clear at the meeting that such an association undoubtedly will meet with success, but the scope of the activity of the association was not clearly defined. It appears that one of the main objects is to form a combination for regulating shows and exhibitions of machine tools.

* * *

According to a report issued by the Society of German Machine Tool Builders, the machine tool trade improved materially during the first six months of 1910 as compared with 1909. The exports of machine tools amounted to 26,870 metric tons, which is considered good, although it is less than the exports in the first six months of 1907 and 1908, which were 27,387 metric tons and 30,256 metric tons, respectively.

PROGRESS AT OAKLEY

At Oakley, Ohio—the new and attractive industrial community near Cincinnati—the Cincinnati Planer Co.'s plant is completely installed and in operation. A descriptive article on this plant appeared in the June, 1910, number of MACHINERY. The Cincinnati Milling Machine Co. is operating both its plants at Cincinnati and Oakley; at the latter place about three hundred men are employed.

The Cincinnati Bickford Co. has just finished moving its Spring Grove Avenue and Bickford plants, which are being consolidated in the new works at Oakley. The machinery and material in the two plants totaled over 4,000,000 pounds and the work of getting all this installed and in running order is now progressing rapidly. It is expected that the Oakley works will be in running order by January 15, and the consolidation of the two plants will result in many economies of time and labor.

* * *

The Cunard Steamship Co. has invited tenders for the construction of a liner which will be slightly larger than the two new White Star liners now building. The new Cunard vessel will be 885 feet long and 95 feet wide, with 50,000 tons' displacement. The speed for which it will be designed will be 23 knots. Provision will be made for 3800 passengers, besides the crew.

* * *

PERSONALS

Leonard Munns, commercial manager of Cammell, Laird & Co., Sheffield, England, is in the United States in the interests of his firm.

John A. Logan, formerly brass-foundry foreman for the National Cash Register Co., Dayton, Ohio, has taken a similar position with the Fairview Foundry Co., Detroit, Mich.

H. C. Jones, formerly with the Warren Screw Co., Detroit, Mich., has taken a position as outside lathe demonstrator for the Lodge & Shipley Machine Tool Co., Cincinnati, Ohio.

J. W. Carrel, general sales manager for Lodge & Shipley Machine Tool Co., Cincinnati, sails January 5 on the steamship *Amerika* for a four months' business trip in Europe.

Francis J. Armstrong has entered into a partnership with his father, Charles G. Armstrong, consulting engineer of New York, under the firm name of Charles G. Armstrong & Son.

R. B. Shaw has been appointed Cleveland manager for Hill, Clarke & Co. Mr. Shaw until recently was sales manager of the machinery department of the Davis Sewing Machine Co., Dayton, Ohio.

J. A. Bennett, who for the past two years has been mechanical engineer for the Lodge & Shipley Machine Tool Co., has taken the position of master mechanic for the Studebaker Bros. Mfg. Co., South Bend, Ind.

William Snyder, formerly master mechanic for the Fulton Bag & Cotton Mills, Atlanta, Ga., has taken the position of chief mechanical and electrical engineer for the Georgia Marble Co. and Blue Ridge Marble Co., Tate, Ga.

F. G. Bolles, commercial engineer of the Allis-Chalmers Co., has resigned to accept a partnership with C. A. Tupper and others in the Reliance Engineering and Equipment Co., with offices in 415-16-17 Engineering Building, Milwaukee, Wis.

Charles M. Ams, president of the Max Ams Machine Co., Mt. Vernon, N. Y., has returned from a successful three months' trip in England and the Continent where he established branch houses for the sale of his company's machines and products.

F. O. Hoagland, who for the last one and one-half year has been chief mechanical engineer of the Remington Arms Co., Ilion, N. Y., has been appointed acting works manager of the works, and in addition will continue to supervise those departments under him as chief mechanical engineer.

C. C. Tyler, who for the last two and one-half years has been works manager of the Remington Arms Co., Ilion, N. Y., has been appointed general manager of works in charge of the general administration and operation of the Remington Arms Co. and the Union Metallic Cartridge Co., Bridgeport, Conn. His authority will extend over all employes of these works.

C. H. Norton, of the Norton Grinding Co., was recently elected president of the newly organized Worcester Publicity Association, Worcester, Mass. The objects of the association are to assist in the advancement of Worcester by studying and improving the methods of business through advertising, and to serve as a publicity bureau for all Worcester business associations.

OBITUARIES

Daniel Arthur, vice-president of the Arthur Co., New York, was killed by a railroad train November 29, aged forty-four years.

Charles Joseph de Berard died at his home in Norwood Park, Chicago, November 28, aged sixty-one years. He was associated with Robert Tarrant in the machine shop business for twenty-five years, and was a stockholder and director in the Tarrant Foundry Co.; he was also secretary and treasurer of the Felt & Tarrant Mfg. Co. of Chicago.

David Hunt, Jr., general manager of manufacturing for the Everett, Metzger, Flanders Co., Detroit, Mich., was killed in an automobile accident near Yale, Mich., November 26. The party in the car were returning from a rabbit hunt and comprised Charles Adams, general superintendent of the E. M. F. Co., Morgan Kavanaugh, the head of the drafting department, Lee M. White, chief inspector, and several other gentlemen. Mr. Adams was driving the machine, which skidded and overturned down a steep clay embankment. Recent rains had made the road slippery, and the accident appeared to have been unavoidable. Mr. Hunt was about thirty-five years old, a Harvard graduate, and began his manufacturing career as a machine operator in a shop owned by his father at Watertown, Mass., in which the first locomobile was constructed, and Mr. Hunt designed much of the machinery used in that car. Of that shop he became foreman and manager, leaving to fill a position as salesman with Manning, Maxwell & Moore, making his way in a few years to the position of Cleveland manager of that firm, which he left to become treasurer and sales manager of the Baush Machine Tool Co., of Springfield, Mass. After two years with this firm he became general sales manager of the Warner & Swasey Co., where he was for six years. The entire manufacturing of the E. M. F. Co. was in Mr. Hunt's hands, and he received reports from the works managers of each of the various plants, utilizing his knowledge to perfect manufacturing plans which he had laid out. Mr. Hunt was widely known to machinery manufacturers and users, and his sudden death was a great shock to his many warm friends all over the country.

* * *

COMING EVENTS

December 31-January 7.—International Automobile Show, Grand Central Palace, New York.

January 7-21.—Association of Licensed Automobiles' tenth annual exhibition of automobiles and automobile appliances. M. L. Downs, 7 E. 42d St., New York.

January 18-19.—Annual meeting of the American Society of Civil Engineers, 220 W. 57th St., New York. Charles W. Hunt, secretary.

January 24-26.—Annual meeting of the American Society of Heating and Ventilating Engineers, New York. W. M. Mackay, secretary, P. O. Box 1818, New York.

January 28-February 11.—Tenth Annual National Automobile Show under the auspices of the National Association of Automobile Manufacturers, Inc., in the Coliseum and Coliseum Annex, Chicago. S. A. Miles, manager, New Southern Hotel, Chicago.

June 14-16.—Annual convention of the American Railway Master Mechanics' Association, Atlantic City, N. J. Joseph W. Taylor, secretary, Old Colony Bldg., Chicago.

June 19-21.—Annual convention of the Master Car Builders' Association, Atlantic City, N. J. Joseph W. Taylor, secretary, Old Colony Bldg., Chicago.

NEW BOOKS AND PAMPHLETS

OFFICIAL CATALOGUE OF THE INTERNATIONAL CENTENNIAL RAILWAY AND TRANSPORTATION EXPOSITION OF THE ARGENTINE REPUBLIC, 270 pages, 7 x 10 inches. Price 50 cents.

This catalogue, which gives full particulars of the exposition held in Buenos Ayres from May to November, 1910, is devoted principally to the various exhibits. In all, there were some 3060 exhibits mostly from the different exporting nations, such as the United States, Great Britain, and Germany. The catalogue is divided into sections, one for each of the exhibiting countries. Under the name of the firm exhibiting, are given particulars as to place of manufacture, and the nature of the product exhibited. From the nature of the exposition, the majority of the exhibits were of machinery, adapted to railway and transportation purposes.

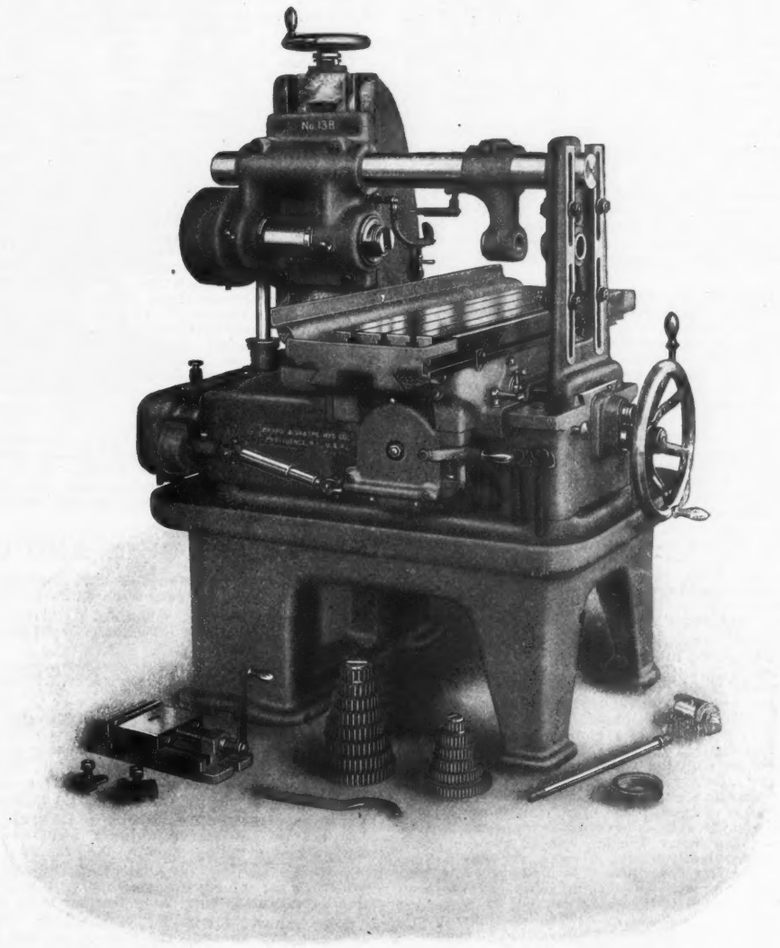
MECHANICAL WORLD ELECTRICAL POCKET BOOK FOR 1911. 270 pages, 4 x 6 inches, 68 illustrations. Published by Emmott & Co., Ltd., 65 King St., Manchester, England. Price 6d. net.

This annual pocket-book makes its appearance for 1911 in a more comprehensive and complete state than ever before, each year showing a considerable betterment. In this issue, the descriptive matter has been materially condensed, thereby affording space for a number of new tables. These include tables on current densities, permissible temperature rise, percentage losses in electrical machinery, units of illumination, current consumed by incandescent lamps, life of glow lamps, depreciation allowances, as well as other convenient tables. The accumulator notes have been rewritten and extended, and the sections on circuit-breakers, electricity in coal mines, and boosters, have been similarly treated. Besides, a new section on liquid starters or water rheostats has been introduced. That the electrical part is being made more and more the predominating feature, is emphasized by the fact that the sections on the mechanical means of transmitting power have been condensed.

UNIVERSITY OF ILLINOIS ENGINEERING EXPERIMENT STATION BULLETINS. 6 x 9 inches. Published by the University of Illinois, Urbana, Ill.

These are the bound volumes of the bulletins issued from time to time by this experimenting station. Volume IV contains bulletins 27 to 34, on: "Tests of Brick Columns and Terra Cotta Block Columns"; "A Test of Three Large Reinforced Concrete Beams"; "Fuel Tests with Illinois Coal"; "Tests of Reinforced Concrete Beams—Re-

A new machine for the rapid and economical production of duplicate parts



No. 13B Plain Milling Machine

Longitudinal Feed, 34"; Transverse Feed, 6"; Vertical Adjustment, 12"

This machine is the latest addition to our line of constant speed drive machines. It is equipped with a friction clutch driving pulley which permits of belting direct from the main line.

Three points of particular importance should be noted. First, it is readily adapted to motor drive. Second, it is rigidly constructed, the spindle is solidly supported and the bed and saddle are designed to give maximum support to the table under heavy cuts. Third, it can be operated with convenience and facility, levers and hand wheel being located where they can be easily reached.

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sistance to Web Stresses;" "On the Rate of Formation of Carbon Monoxide in Gas Producers"; "Fuel Tests with House-heating Boilers"; "The Occluded Gases in Coal"; "Tests of Tungsten Lamps," and "Tests of Two Types of Tile-Roof Furnace under a Water-tube Boiler." Volume V includes bulletins 35 to 42 on a study of "Base and Bearing Plates for Columns and Beams"; "The Thermal Conductivity of Fire-clay at High Temperatures"; "Unit Coal and the Composition of Coal Ash"; "The Weathering of Coal"; "Tests of Washed Grades of Illinois Coal"; "A Study of Heat Transmission"; "Tests of Timber Beams"; and "The Effect of Keyways on the Strength of Shafts."

SHOP KINKS. By Robert Grimshaw. 393 pages, 5½ x 7½ inches, 224 illustrations. Published by Norman W. Henley & Son, New York. Price $2.50.

The popularity of this handy little shop book is evidenced by the fact that it is now passing into its fifth edition. Originally it was the outcome of a suggestion offered to the author many years ago when entering a large machine shop. This suggestion was that he should keep a note-book of what he observed, and so successful did this prove that the results were embodied in a book. In the various editions through which it has passed, it has from time to time been improved so that now it presents a comprehensive list of machine shop kinks, methods, and devices for cheaply producing work, most of the ideas being from some of the largest shops in this country and in Europe, and representing a long period of contact with some of the largest machinery builders in the world. Many of the machine shop suggestions embodied, however, are from leading technical journals, some of the best of the suggestions given in these papers being included. Nearly every phase of machine shop practice is dwelt upon in a brief, breezy manner that should appeal to the average man in the shop.

MACHINE SHOP PRIMER. By Fred H. Colvin and Frank A. Stanley. 148 pages, 6½ x 8½ pages, 508 illustrations. Published by the McGraw-Hill Book Co., New York. Price $1.00, net.

This book is decidedly unique in its general make-up, and has a style peculiarly its own. There are three sectional divisions. The first part contains 508 illustrations of the various tools, machines, and devices commonly found in the machine shop arranged in alphabetical sequence. No names are given with the illustrations, merely the figure number, it being the purpose of the book to test a man's knowledge and ability to name all these machines, and, if the necessary information is not known, by turning to Section 2 of the book, all the names are listed, in the same alphabetical order as the illustrations. The third section consists of a dictionary of shop terms, wherein things from an angle plate to a wrench are defined. Where there are illustrations in the first section of the terms being defined, reference is made to that fact in the explanation, and the figure number given. While containing practically nothing new, it fulfills the intentions of the authors, who realize the fact that the first step toward a clear understanding of practical shop work, is a knowledge of the names of the machines, tools, and appliances used. The book was prepared to aid both students and instructors in this line of work, and should prove helpful to apprentices learning the trade.

IRON AND STEEL. By Hugh P. Liemann. 354 pages, 3 x 7 inches. 43 illustrations. Published by the McGraw-Hill Book Co., New York. Price $3.00, net.

This is a convenient, handy sized encyclopedia of iron and steel, and allied industries, gotten out in handbook style, with flexible leather cover, and printed on thin India paper, forming a reference book of less than half an inch thick. The method of treatment is unusual, the book being a combination of dictionary, encyclopedia, and handbook, possessing as well as omitting some of the features of all. To begin with, it is like a dictionary or encyclopedia, in that names and descriptions are introduced alphabetically. The definitions or descriptions of isolated terms or processes are found under the respective headings, while those employed in connection with some special subject or process, are under the latter, the location of the definition being given opposite the alphabetically arranged name, so that a compact arrangement of definitions and descriptions is made possible, and is carried out in a practical manner. Everything irrelevant to iron and steel production, and the industries closely related, is dispensed with, in order to make the book bear as closely as possible on the subject in hand, without containing matter uninteresting to the millman and metallographist for whom the book was primarily written.

MECHANICAL DRAWING FOR PLUMBERS. By R. M. Starbuck. 111 pages, 6½ x 9¼ inches. 150 illustrations. Published by Norman W. Henley & Son, New York. Price $1.50.

In this book is embodied a series of articles written by Mr. Starbuck for *The Plumbers' Trade Journal*, prepared by the author because of a conviction that plumbing drawing is a valuable and practical acquisition for the plumber. The following are the chapters contained: Value to Plumber of Knowledge of Drawing; Perspective Versus Mechanical Drawing in Showing Plumbing Construction; Correct and Incorrect Methods; Floor and Cellar Plans and Elevation; Use of Triangles; Drawing Plumbing Elevations and Fittings; Instructions in Drawing Plumbing Elevations; The Drawing of Plumbing Fixtures; Drawings of Fixtures and Fittings; Inking of Drawings; Shading of Drawings; Sectional Drawings; Plumbing Elevations; Elevations of Separate Parts of the Plumbing; Elevations from Architect's Plans; Drawing of Detail Plumbing Connections; Architect's Plans and Plumbing Elevations of Residence; Plans and Plumbing Elevations of Six-Flat Building; Drawing of the Various Parts of the Plumbing System; Use of Architect's Scales; Special Features in the Illustrations of Country Plumbing; Drawing of Wrought Iron Piping; Valves, Radiators, Coils, etc.; and Drawing of Piping to Illustrate Heating Systems. Much of the contained information is drawn from the author's personal experience gained in the pursuit of the plumbing business, and the thought of the personal benefit derived from a knowledge of this subject has led to his writing this book. Being well illustrated, it carries out the main desideratum of a book on drawing, by practically exemplifying what is implied by the text.

QUALITATIVE CHEMICAL ANALYSIS. By J. I. D. Hinds. 265 pages, 6 x 9 inches. Published by the Chemical Publishing Co., Easton, Pa. Price $2.00.

This book is an excellent treatise on qualitative chemical analysis, and is intended to be not only educational, but to have a practical value as well. The subject is developed in such a way as to make the student familiar with the properties and reactions of all the substances with which he deals, and also to so teach him the underlying principles that he will have an intelligent understanding of the processes, and at the same time give him a rapid and accurate practical method of analysis. The subject has been approached from the standpoint of the theory of electrolytic dissociation, solubilities and law of mass action, this method being used principally wherever it was thought a better explanation was thereby afforded. This involved a discussion on ions of both polarities, the kations and anions. The classification of the former is that customarily found, while the latter is essentially the same as given in Boettger's Qualitative Analysis, arranged in a more systematic method for the anion separation and identification. Several new or uncommon methods of analysis are introduced. There are five general divisions of the book. The first on principles and methods of qualitative analysis contains an introductory chapter, followed by chapters on separators, solutions, and reactions. Basic analysis is the subject of the second part, and contains chapters entitled Silver Group, Copper-Arsenic Group, Iron Group, Zinc Group, Barium Group, and Magnesium-Alkali Group. The third section contains the corresponding Acidic Analysis, explained in chapters on Properties and Reactions of the Non-Metals, Acids and Anions, and Separation and Identification of the Acids and Anions. Parts four and five contain a single chapter apiece on Complete Analysis of an Unknown, and Reagents and Tables.

WELDING. By Richard N. Hart. 181 pages, 6½ x 9½ inches. 93 illustrations. Published by McGraw-Hill Book Co., New York. Price $2.50, net.

This book has been compiled to meet the demand for a work containing most of the generally known welding data under one cover, for, while numerous tests have been performed and articles on the subject published, no attempt has thus far been made to present these data in sequence in one book. Much test and cost data are included in the work with a cautioning foreword that it be taken with the proverbial grain of salt, for, while the tests given for iron are standard and cannot be questioned, those given for the special processes are more recent and in most cases are made by interested parties. The book is divided into four parts: "Metals," "Electric Welding," "Hot-flame Welding," and "Thermit," these divisions being introduced by a brief general preface dealing with definitions, and the theories of welding. Under the metals are chapters on Iron, Platinum, Gold, Silver, Aluminum, Copper, Nickel, and Welded Products. The second part on electric welding includes chapters on such processes as La Grange-Hoho, Zerener electric blowpipe, Bernardos arc-welding, and Thomson. Part III, dealing with hot-flame welding, takes up the oxy-acetylene and oxy-hydrogen processes, dealing with the former in detail in the following chapters: Apparatus and Gases, Practice, How to Weld, Adaptability, Typical Welds and Repairs, Acetylene Welding versus Riveting, Repairing Defective Castings, How to Cut Metals, Costs, Chemistry and Thermics, and Testing. In the fourth part which deals with Thermit, chapters are given on History, Apparatus and Rail Welding, Practice, Butt-welding of Pipes, Mending Defective Castings, Thermit in Foundry Practice, Typical Welds, Testing, Lafitte Welding Plate, Ferrofix Brazing Process, Brazing and Soldering, and Glossary of Terms. It forms a comprehensive work on welding in all its branches, and may be considered authoritative, several eminent metallurgists having been consulted in its preparation.

CATALOGUES AND CIRCULARS

BRISTOL CO., Waterbury, Conn. Bulletin No. 140 on Bristol's recording gages for all ranges of pressure and vacuum.

WINFIELD ELECTRIC WELDING MACHINE CO., Warren, Ohio. Pamphlets on Winfield No. 305 electric spot welder, and Winfield No. 336 electric point welder.

ADAMS CO., 847 White St., Dubuque, Ia. The Farwell gear testing machine is described on leaflet No. 821. The description is brief, being limited to a single page.

SOCIETE FRANCAISE DE MACHINES-OUTILS, Saint-Ouen, France. Catalogue describing in detail the combined horizontal and vertical milling machines made by this firm.

LODGE & SHIPLEY MACHINE TOOL CO., Cincinnati, O. Catalogue No. 22 descriptive of the multiple stops for engine lathes, which can be furnished with any of the company's lathes.

GARVIN MACHINE CO., Spring and Varick Sts., New York. Circulars No. 135 on the Garvin milling machine No. 2-A, and No. 152 on Garvin hole grinding machine No. 2.

C. F. PEASE CO., 167 Adams St., Chicago, Ill. Catalogue describing full lines of blue-print machinery, blue-print room supplies, direct white-print machinery, and drafting-room furniture and supplies.

HESS-BRIGHT MFG. CO., Philadelphia, Pa. Sheets Nos. 62 and 63 of series 336, showing the uses of style B bearing mountings without shoulders on shaft, and ball bearing mounting and demounting tools.

GERARD DEVELOPMENT CO., 74 Broadway, New York. Leaflet giving brief description of a series of tests recently conducted by Prof. Pryor on a 100 H.P. Herrick balanced rotary engine, with the results tabulated.

AURORA TOOL WORKS CO., Aurora, Ind., has just issued an attractive catalogue descriptive of the full line of Aurora drills. Each of the various sizes made is illustrated, and specifications of the machines are given.

LEES-BRADNER CO., Cleveland, Ohio. Pamphlet containing an illustrated description of automatic gear generators, with special reference to the No. 5 machine for hobbing spur, spiral and worm gears, and threading worms, made by the company.

WESTINGHOUSE ELECTRIC & MFG. CO., Pittsburg, Pa. Parts catalogues Nos. 6141 and 6143. No. 6141 lists parts for the Westinghouse type 306 interpole railway motor for direct-current circuits, and No. 6143 lists standard metallic brushes for alternating and direct-current circuits.

NEW BRITAIN MACHINE CO., 64 Bigelow St., New Britain, Conn., is distributing a table of three-place logarithms on a celluloid card, of a size suitable for the vest-pocket. The table is accompanied with a leaflet illustrating their use and showing how time can be saved in calculation of engineering problems.

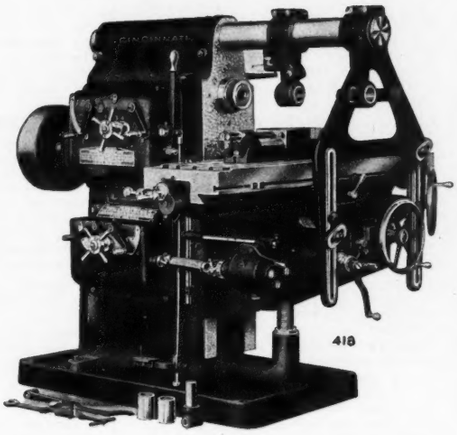
GENERAL ELECTRIC CO., Schenectady, N. Y. Bulletin No. 4662-A is a new edition of the bulletin on watthour meters for switchboard service; No. 4790 deals with electric mine locomotives and their equipment in a detailed manner; and No. 4794 describes the 1200 volt lines of the Milwaukee Electric Railway & Light Co.

BUFFALO STEAM PUMP CO., Buffalo, N. Y. Catalogue No. 230 containing 96 pages, devoted to a description of the single-stage centrifugal pump. The company's complete lines of horizontal and vertical, pulley, motor and engine-driven centrifugal pumps are here listed, the various details of construction being fully dealt with.

MODERN TOOL CO., Erie, Pa. Catalogue of plain, universal and internal grinding machines, Wallace die chaser grinder and universal graduating machines, self-opening screw cutting die heads, adjustable solid dies and milling tools, adjustable tap- and die-holders, friction and positive drive chucks, special lathe chuck and tapping attachments, etc.

FAIRBANKS, MORSE & CO., Chicago, Ill. Catalogue No. TV 1427 shows the new 25 H.P. traction engine recently placed on the market by this concern. This traction engine is driven by a four-cycle gas engine capable of operating on gasoline, benzine, naphtha, or distillate,

The No. 2 High Power Cincinnati Miller



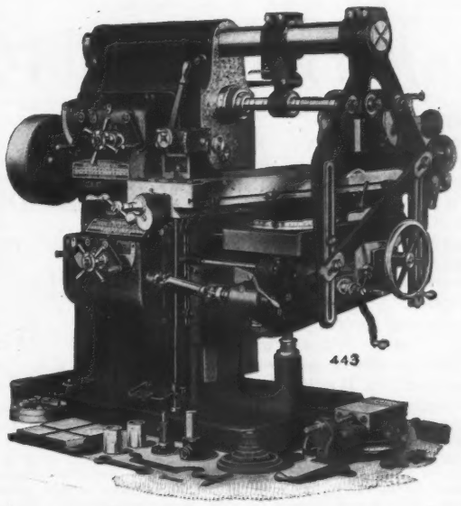
This machine has the manufacturer's standard range. Plain, 28″ x 8″ x 19″. Universal, 25″ x 8″ x 18″.

But it is away ahead of any other No. 2 in other respects.

POWER: It is designed to be fitted with a 5 H. P. motor, and will work that motor up to 50 per cent. overload.

RIGIDITY: Its design throughout is on the box section principle. The service to which each important member is subjected has been determined by scientific investigations as a basis for the detail design. For example: the knee gets chiefly twisting strains; therefore we have made it a webbed box—the strongest rectangular form for resisting torsional strains. The braces are a single piece truss with immense stiffness against the side pressure that comes on the outer arbor bearing.

DURABILITY: All bearing surfaces are many times larger than is actually required for the work. The inside gears are all drop-forged steel, and those chiefly used for speed changes are nickel steel, hardened.



HANDINESS: It is the handiest miller made, is operated entirely from one side; feed and speed indexes direct reading; feed levers also reverse; treadle for quick speed changing.

ACCURACY: Unexcelled.

Ask us for price and delivery.

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI, OHIO, U. S. A.

EUROPEAN AGENTS—Alfred H. Schutte, Cologne, Brussels, Milan, Paris and Barcelona. Donauwerk Ernst Krause & Co., Vienna, Budapest and Prague. Chas. Churchill & Co., London, Birmingham, Manchester, Newcastle-on-Tyne and Glasgow.
CANADIAN AGENT—H. W. Petrie, Limited, Toronto, Montreal and Vancouver. AUSTRALIAN AGENTS—Thos. McPherson & Son, Melbourne.
JAPAN AGENTS—Andrews & George, Yokohama. CUBAN AGENT—Adolfo B. Horn, Havana.
ARGENTINE AGENTS—Adolfo Mantels & Co., Buenos Ayres.

CONTENTS FOR JANUARY

The first column of page numbers applies to the Engineering and Railway Editions; the Second to the Shop Edition.

DIE-CASTING—1. A. C. von Dreele	337	233
SOME SUGGESTIONS FOR INDEXING BOOKS. John S. Myers	341	237
EXTERNAL CUTTING TOOLS—1. Douglas T. Hamilton.	343	239
THE FIELD FOR GRINDING. C. H. Norton	346	242
PRECISION GRINDING. W. A. Viall	349	245
REPAIRING JOURNAL OF A DIRECT-CONNECTED GENERATOR. Observer	351	247
EDITORIAL	352	248
PRACTICAL COST REDUCTION BY RAILROADS	353	
MILLING SCREW MACHINE CAMS. William W. Johnson	354	
CAST-IRON BRACKET USED AS AN OBLIQUE CANTILEVER.	356	
METHOD OF HANDLING BOILER TUBES IN THE CANADIAN PACIFIC SHOPS	358	
THE EFFECT OF KEYWAYS ON THE STRENGTH OF SHAFTS	359	
A SYSTEM FOR LOCATING HEADS OF DEPARTMENTS. Victor White	362	
DESIGN OF AUTOMOBILE TRANSMISSION GEARS—3. M. Terry	363	
AEROPLANES AND AIRSHIP ENGINES	365	
INS AND OUTS OF GEAR HOBBING. Ralph E. Flanders	369	
PNEUMATIC PRESS FOR REMOVING SPRING BANDS. S. Wheal	375	
THE AIR BRAKE AS RELATED TO PROGRESS IN LOCOMOTION	376	
WHAT IS A MACHINE TOOL? T. S. Bentley	378	
INTERESTING TOOLS AND METHODS OF CINCINNATI SHOPS—6. Ethan Viall	380	
AN IMPROVEMENT ON THE MANNHEIM SLIDE RULE. Designer	384	
LIMITATIONS IN DESIGN OF THE WUST HERRINGBONE GEAR. Percy C. Day	384	
SOME JIG AND FIXTURE DESIGNS. Franklin D. Jones.	385	249
SOLVING A PRACTICAL PROBLEM BY SIMULTANEOUS EQUATIONS. Howard Terhune	389	253
THE SYSTEMATIC SCRAP BOOK. R. E. Ashley	390	254
MACHINE SHOP PRACTICE—A VERTICAL BORING-MILL OPERATION	391	255
MACHINE TOOL DESIGN A LA COBHOUSE	392	256
TOOLMAKER'S FILES. E. P. Reichhelm	393	257
PUNCH AND DIE FOR BLANKING HEXAGON NUTS. Charles Pabeshutz	394	258
TURNING RUBBER WASHERS. Frank Lang	394	258
A MICROMETER STOP FOR THE LATHE CARRIAGE. A. J. Petersen	395	259
A SYSTEMATIC SCRAP-BOOK. Designer	395	259
SUB-PRESS DIE FOR BLANKING THIN WASHERS	396	260
TEMPLET USED IN GRINDING CIRCULAR FORMING TOOLS FOR SCREW MACHINES. F. W. Randall	396	260
I-BEAM TROLLEY DESIGNS. S. M. Ransome	396	260
METHOD OF REPAIRING A DRILL SOCKET. John E. Cook	397	261
DEPTH GAGE FOR TAILSTOCK DRILLING. W. S. Leonard	397	261
CUTTING THREADS HAVING FRACTIONAL PITCHES. William Fuess	397	261
A DANGEROUS DRIP-CUP. Frank H. Mayoh	398	262
A HANDY BORING-MILL CHUCK. James Clark	398	262
MOUNTING BLUEPRINTS. H. D. Aylsworth	399	263
CALIPERS FOR MEASURING OVER A FLANGE. Charles H. Bettle	399	263
KEYSEATING LARGE SHAFTS. John Reid	399	263
INSERTING SMALL SCREWS. Fred Henke	399	263
PREVENTING A PENCIL POINT FROM BREAKING. Designer	400	264
MACHINE FOR GRINDING SQUARE HOLES	400	264
REBORING LARGE WHEELS ON A SMALL LATHE	400	264
NEW MACHINERY AND TOOLS	401	265
A MACHINE FOR MAKING BARBED WIRE	422	286

and can drive in either direction. A very neat power transmission gear is employed.

AMERICAN SWISS FILE & TOOL CO., 24 John St., New York. This descriptive price list of American Swiss files, forms a complete fine-file catalogue, illustrating and listing the various styles made by this company, which specializes on fine files exclusively. These "files of precision" are distinctly an American product, and the line being fully developed, offers a wide range for selection, for toolmakers' and die-sinkers' uses.

INGERSOLL-RAND CO., New York. Form No. 3002 descriptive of class A-1 straight-line, steam-driven, single-stage air compressors, and form No. 9002 devoted to Davis calyx diamondless core drills, are typical of the publications issued by this firm. In the former, the chief mechanical constructional features are dwelt upon fully, while in the latter the drill in actual use, and the results of its use are described, as well as its construction.

OSBORN MFG. CO., Cleveland, O. Catalogue No. 131 descriptive of the full line of foundry supplies, molding machines, brushes, brooms, and hardware specialties marketed by this concern. Under the first two heads come the various kinds of Osborn molding machines, grinding machines, tumbling barrels, core ovens, barrows, ladles, and molders' tools as well as many other articles. A very large variety of brushes of all kinds for numerous purposes, are also included in the catalogue, this being one of the firm's main lines.

JOSEPH T. RYERSON & SON, Chicago, Ill. Two catalogues, one of which is on power presses, describing foot, bench, inclinable, power, wiring, horn, pillar, and toggle presses, special reference being made to the special, positive, instantaneous clutch, which is separately described. The other catalogue, on emery wheel machinery opens with a general talk on emery wheels with data for grade selection, and proceeds to describe and list their full line of abrasive machinery.

GENERAL ELECTRIC CO., Schenectady, N. Y. Bulletins No. 4780 illustrating and describing the Gem or metallized filament incandescent lamp; No. 4781 illustrating the G-E Magda incandescent lamp for street lighting; No. 4782 on direct current exciter panels; No. 4786 devoted to signals, auxiliary apparatus, and materials; the third edition of No. 4602-B descriptive of automatic voltage regulators for direct current generators; and Pamphlet B-3006 containing an article on luminous and flame arcs, versus open and enclosed carbon arcs for street lighting, read before the National Electric Light Association.

CARLYLE JOHNSON MACHINE CO., Manchester, Conn. Catalogue E for 1911 on the Johnson friction clutches, comprising 45 pages, 4½ by 7 inches. This catalogue is larger and more comprehensive than any before issued by the company. It deals almost exclusively with the driving of machinery through friction clutches, special attention being given to the driving of machinery from line-shafting, thus eliminating cross belting, countershafting, etc. Special mention is made of clutches for cut-off coupling work for use with marine motors. The lists are complete, extending to clutch parts which are numbered to correspond with the numbers indicating the parts on sectional views.

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION, Charles E. Hildreth, secretary, Worcester, Mass. Official report of the ninth annual convention held in New York, October 25 and 26, 1910. In addition to a detailed account of the business transactions, all the papers read before the meetings are given, along with the discussions that followed each delivery. The following are the papers presented: "Who should pay the Expenses of a Representative from the Factory when sent out at the request of a Dealer to help close a Deal?"; "The Use of Ball or Roller Bearings in Machine Tool Construction"; "Concrete *vs.* Wood Flooring"; "Advertising"; and "The Design and Construction of Machine Tools from the User's Standpoint." The reports of different committees previously appointed, were also received.

EUGENE DIETZGEN CO., Chicago, Ill. The ninth edition of its drawing materials and surveying instruments catalogue might well be termed an engineers' instrument treatise, so complete is it. It is a book, 6 by 9 inches, containing 555 pages attractively arranged. So many and varied are the lines described and catalogued, that even a partial list would be impossible. Every drafting room requisite is given, from drawing and blue-print papers to drawing instruments. In this class may be included many special topographical drafting devices. Following this is a complete array of all kinds of surveyors' instruments, chains, transits, theodolites, etc., and many other civil engineers' requirements. In addition to these few mentioned might be noted planimeters, anemometers, current meters, and other recording devices for varied uses. A good list of books on drawing and scientific subjects, is included.

TRADE NOTES

AMERICAN EMERY WHEEL WORKS, Providence, R. I., was awarded a gold medal at the Brussels Exposition for its exhibit of grinding wheels and abrasive products.

EDGAR ALLEN & Co., Chicago, Ill., announces the appointment of Schrock & Squires, 291 Pearl St., New York, as the eastern agents for their tool steels, large stocks of which will be carried by them in their warehouse, to promptly meet customers' requirements.

PEERLESS AUTOMATIC MACHINE CO., Cleveland, Ohio, manufacturer of automatic screw machines, whose plant was burned out a few months ago, is now located in its new factory at West 77th St. The shop building is 60 by 300 feet long. The company is now in position to take care of orders.

FOSTER ENGRAVING CO., Newark, N. J., is having its pressure regulators made on a commercial scale in accordance with the new patent laws of Germany, Austria, Hungary, Belgium and France. Arrangements for foreign manufacture were made by Dr. Robert Grimshaw of Dresden, Germany.

LONGYEAR & HODGE, Marquette, Mich., have been located in their new, fully-equipped factory for a short period. The whole plant has been arranged with the idea of the rapid and efficient production of their special lines which consist of diamond drills, and drill machine parts, though the plant is also equipped for doing a general machine shop business.

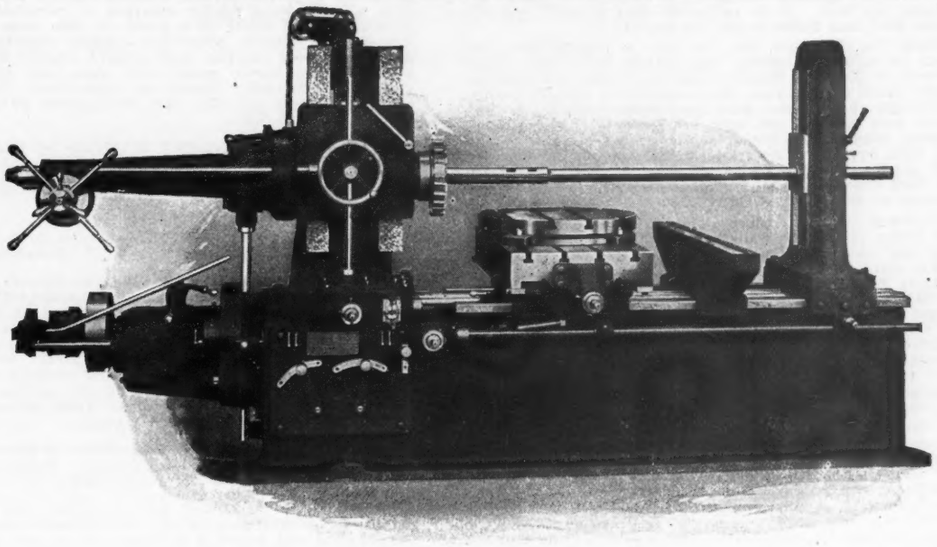
MAX AMS MACHINE CO., Mt. Vernon, N. Y., has, through its president, Mr. Charles M. Ams, established branch houses in England and on the continent for the sale of its sanitary solderless sealed can and the Ams double seamers. The new Ams factory at Turin, Italy, is completed and thoroughly equipped. It is one of the largest in southern Europe.

INSTITUTE OF OPERATING ENGINEERS, 29 W. 39th St., New York, has issued a prospectus containing the proposed plan and scope of its work. Several branches are now in process of formation throughout the country and the work has already been adopted in the extension course at Teachers' College. The chairman of the executive committee is J. C. Jurgensen; secretary, M. W. Rice.

R. D. NUTTALL CO., Pittsburg, has introduced an innovation into railway equipment parts by bringing out casehardened gears and pinions. While many of these have been in service for some time, the announcement has been deferred until experience showed that the parts would stand up under severe conditions. So satisfactory have been the results, that it has been decided to add these gears and pinions to the regular lines.

VONNEGUT HARDWARE CO., Indianapolis, Ind., separated its machinery department from the rest of its business January 1, 1911, and is operating it under the name of the Vonnegut Machinery Co., as a branch of the Vonnegut Hardware Co. The Vonnegut Machinery Co., will be located in the building formerly occupied by the Francke Hardware Co., 43 to 45 South Meridian St. The sales organization will include Messrs. Anton Vonnegut, Charles Rassman and C. B. Williamson.

MORGAN ELECTRIC CO., Alliance, Ohio, has erected a large electric sign on the smokestack of its plant. The sign spells M O R G A N, the letters being hung perpendicularly down the side of the 400-foot smokestack. The sign is readable a mile and a half away. It was built by the Dittenhafer Sign Co., Canton, Ohio, of a rust-resisting "Toncan" metal made by the Stark Rolling Mill Co., of the same place. The letters are six feet high and the width of stroke of each



THIS is about the time the wise ones are working on improved designs. The best machine on which to make the new model is the

"PRECISION"

Boring, Drilling and Milling Machine

which has screws, dials and workmanship all through that are REALLY **"PRECISION"**. Then make as many more machines as you like on the **"PRECISION"**, WITHOUT JIGS; then, any time you like, MAKE YOUR JIGS on the **"PRECISION". No shop can afford to be without it.**

LUCAS MACHINE TOOL COMPANY

(NOW AND ALWAYS OF)

CLEVELAND, OHIO, U. S. A.

AGENTS—C. W. Burton, Griffiths & Co., London. Alfred H. Schutte, Cologne, Brussels, Liege, Paris, Milan, Bilbao, Barcelona. Schuchardt & Schutte, Berlin, Vienna, Stockholm, St. Petersburg, Copenhagen, Budapest. Overall, McCray, Ltd., Sydney, Australia. Andrews & George, Yokohama, Japan. Williams & Wilson, Montreal.

is about one foot. 310 electric lamps of 8 candlepower each are used to illuminate the sign. It is estimated that it will cost the company between $800 and $1000 a year to operate it.

KEWANEE BOILER CO., Kewanee, Ill., has built a foundry and pattern shop which in point of lighting and heating will rank among the best structures in Illinois. Shower baths have been installed for the workmen and other conveniences characteristic of modern plants. The following changes in personnel have been made: H. Zable, foreman of the gray iron foundry has been promoted to superintendent of the boiler shop, taking the place of Seldon Miller, resigned; John A. Barnes has been appointed foreman of the foundry in place of Mr. Zable, and A. W. Cochrane, superintendent of the radiator department, has been appointed superintendent of both foundrys and still retains charge of the radiator department.

RICHARDSON-PHENIX CO., Milwaukee, Wis., a consolidation of the Sight Feed Oil Pump Co., of Milwaukee, and the Phenix Lubricator Co. of Chicago, has completed the equipment of its new factory at Milwaukee. This plant is claimed to be the largest in the country devoted exclusively to the manufacture of lubricating devices. The company will manufacture Richardson and Phenix mechanical lubricators, individual oiling systems, power plant oil filters and general appliances for cylinder and machinery lubrication. Wilbur E. Richardson, president of the company, is in personal charge of the works; J. Wm. Peterson has been appointed general sales manager with headquarters in the Hudson Terminal Bldg., New York; and J. S. Ward is in charge of the Western sales office in the First National Bank Bldg., Chicago.

ROYERSFORD FOUNDRY & MACHINE CO., 54 North Fifth St., Philadelphia, Pa., has opened a branch office at 149 Queen Victoria St., London, E. C., which is in charge of Mr. Theodore Butler. The largest stock of power transmission machinery to be found in Great Britain and on the Continent will be carried at the branch store. Mr. John D. Sells, general manager of the company, has just returned from a three months' business trip to Europe, where he went to extend the company's connections for the sale of the Sells roller bearing and the general line of power transmission machinery. He reports business at home and abroad as being very good. In spite of the fact of having erected an additional building, 50 x 150 feet, the company is compelled to run twenty-four hours a day in order to meet the demands for its products.

CAMMELL, LAIRD & CO., 25 Cliff St., New York, are preparing to move into their new premises at 34 Cliff St. The building obtained is an old four-story structure, of hewn oak beams formerly used by a wholesale house. It has been completely remodeled, and extended back to about twice its former depth. In addition, the front of the building has been materially altered and now presents a modern appearance. The building is well adapted for their requirements, for, from the nature of its former use, it is strongly built. The offices will be located on the top floor, and the second floor is to be arranged for small stock such as small tools, and tool-holders. The first floor, divided down the center with vertical racks, making four rack walls, is to be devoted to special steels, while the ground floor, similarly arranged with racks, is to be devoted to the storage of the H. R. D. high-speed and Cammell No. 2 steel. The basement is for heavy storage purposes, and at its front end, under the sidewalk, a hardening room is being arranged. In the forward part of the main floor, there is a single track craneway, which passes out of the door, and is connected to a swinging jib, to facilitate the handling of materials.

MISCELLANEOUS

Advertisements in this column, 25 cents a line, ten words to a line. The money should be sent with the order. Answers addressed to our care will be forwarded. Original letters of recommendation should not be enclosed to unknown correspondents.

AGENTS IN EVERY SHOP WANTED to sell my sliding Calipers. Liberal commission. ERNST G. SMITH, Columbia, Pa.

AGENTS wanted in every works in Great Britain where draftsmen, machinists and tool-makers are employed, to represent MACHINERY and take orders for MACHINERY'S remarkably successful Reference Books. Special offers in force in Great Britain for a limited time only, give a choice of 65 Reference Books and 20 new Data Books sold at a shilling per copy, and a subscription for MACHINERY, cash or credit. No charge is made for credit. We supply sample copies and advertising matter describing the books in detail for distribution in Engineering Works. Write us for full information. WM. DAWSON & SONS, LTD., Cannon House, Bream's Bldgs., London, E. C.

DESIGNING, DETAILING AND TRACING WORK on engines, machinery, tools, automobiles and structures, wanted. Shop plans and equipment. Address Clark & King, 615 Brisbane Building, Buffalo, N. Y.

DRAFTSMEN AND MACHINISTS.—American and foreign patents secured promptly; reliable researches made on patentability or validity; twenty years' practice; registered; responsible references. EDWIN GUTHRIE, Corcoran Building, Washington, D. C.

DRAWINGS, TRACINGS, BLUE PRINTS made. Thorough and reasonable. Hanau Engineering Co., 74 Lafayette St., New York.

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